

JANUARY 19, 1961

MACHINE

DESIGN

A PENTON PUBLICATION — BIWEEKLY

MF

Mr. Stevens Rice
University Microfilms
313 North First Street
Ann Arbor, Michigan

Dynamic Properties of HYDRAULIC MOTORS

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FAIRBANKS

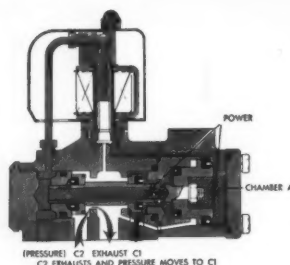
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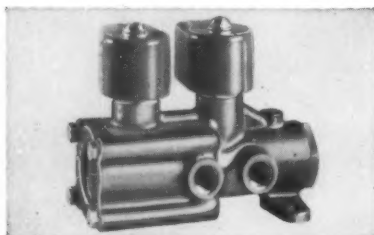
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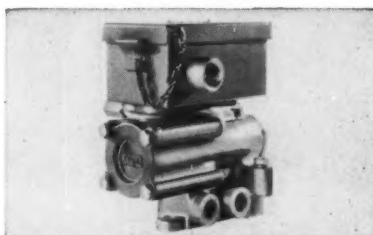
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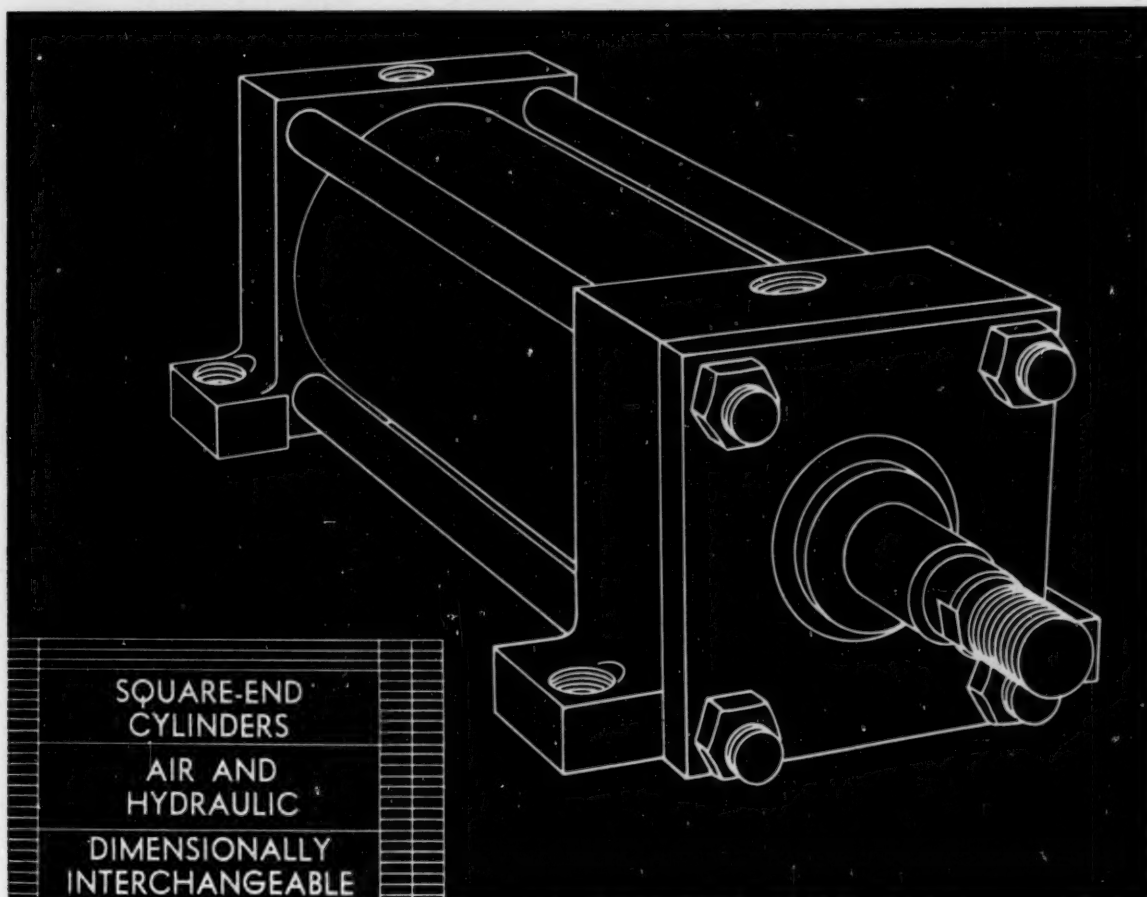
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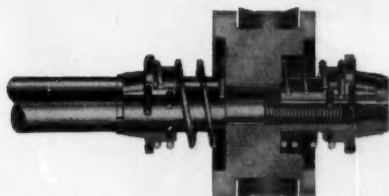
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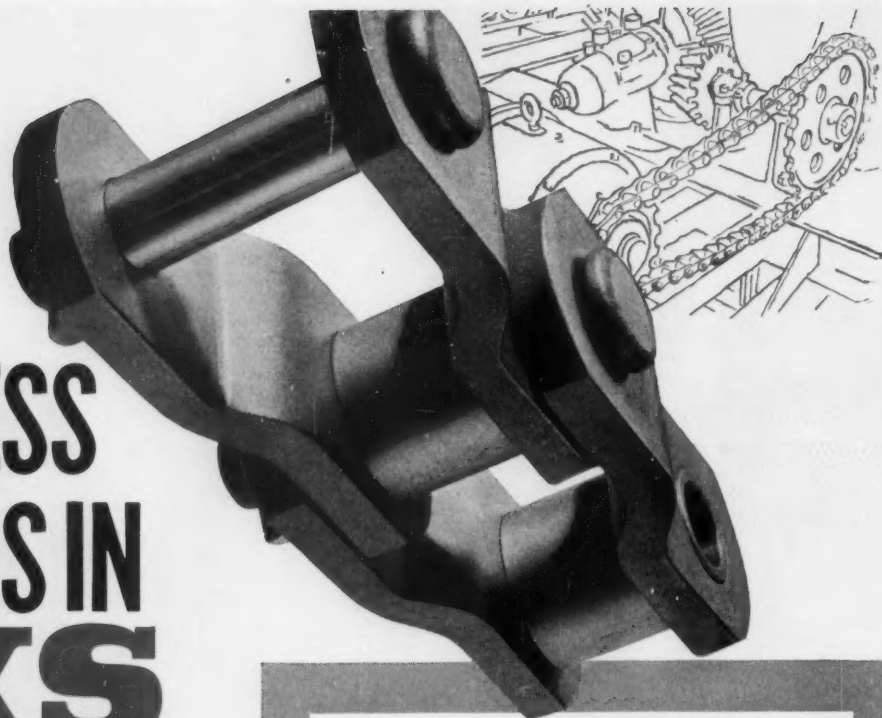
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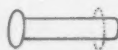
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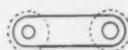
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Front Cover: Dynamic response curves of a hydraulic system take on a glamorous look in artist George Farnsworth's cover design. For the down-to-earth facts on dynamic properties of hydraulic motors, see J. T. Hansen's article beginning on Page 132.

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THE SEALS BOOK

1961 Edition

A basic reference manual on seals, packings, and gaskets, being mailed separately—Watch for it.

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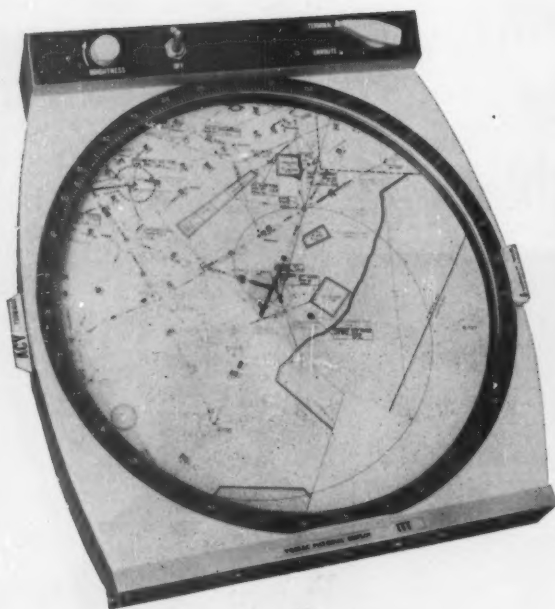
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The machines you design can be more compact, lighter weight and lower cost by using Gates Super HC High Capacity V-Belt Drives. Because of exclusive construction features, this high capacity drive — industry's first — can often cut in half the space formerly required for a V-belt drive. Gates Super HC Drive is your best assurance that your power transmission unit will not soon become obsolete. The Gates Field Engineer near you is an experienced, fully-qualified drive design expert. Contact him for drive design help.

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GP-3



VORTAC display consists of a 12-inch diameter map overlaid by two transparent discs, one of which is inscribed with a spiral line, the other with a straight radial line. Aircraft's position is the intersection of the spiral and straight lines, which represent distance and bearing, respectively.

VORTAC: "Visual IFR" for Collision-Proof Flight

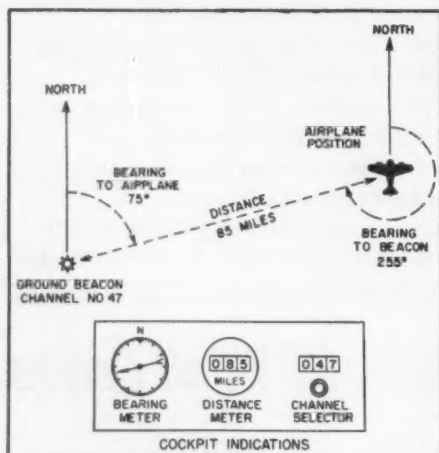
TETERBORO AIRPORT, N. J.—An easy-to-read cockpit display which shows the exact position of an aircraft over a selected portion of a map may, in a large measure, eliminate

the danger of in-flight collisions.

Designed for integration with the Federal Aviation Agency's new VORTAC air-navigation program (more than 200 VORTAC stations

will be operational this year), the display was created by ITT Federal Laboratories, Div. of International Telephone and Telegraph Corp.

The fully transistorized VORTAC display is about as easy to operate as a home slide projector, according to ITT engineers. After inserting the "deck" of maps in a logical sequence that meets his flight plan, the pilot tunes in the VORTAC station servicing his departure area and takes off. As he flies out of the terminal pattern, he switches to his first enroute VORTAC channel and simultaneously changes to his next map, which automatically pops into place as the used one is removed. He repeats the process each time his map indicates that the aircraft is flying into a new map area. The portable self-contained device requires no additional black boxes and can be mounted between the pilot and co-pilot for viewing by either.



VORTAC combines the commercial VOR (very high frequency omnirange) system in use by airlines for more than a decade with the TACAN (tactical air navigation) system, recently developed for U. S. military aircraft. VOR is chiefly a directional system which tells an aircraft its heading. Pilots can obtain distance information only through computations based on multiple bearing fixes. TACAN, a radio navigation system of the polar co-ordinate type (left), gives a pilot distance as well as heading, without cockpit computation.

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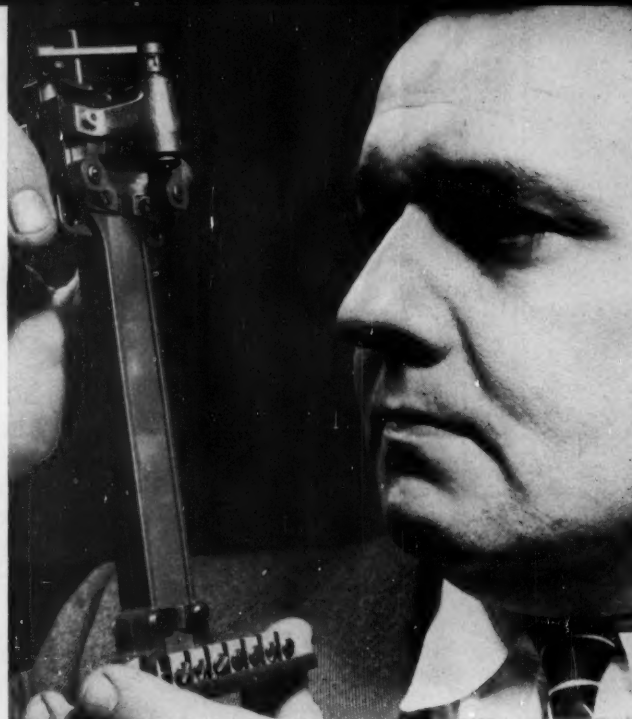
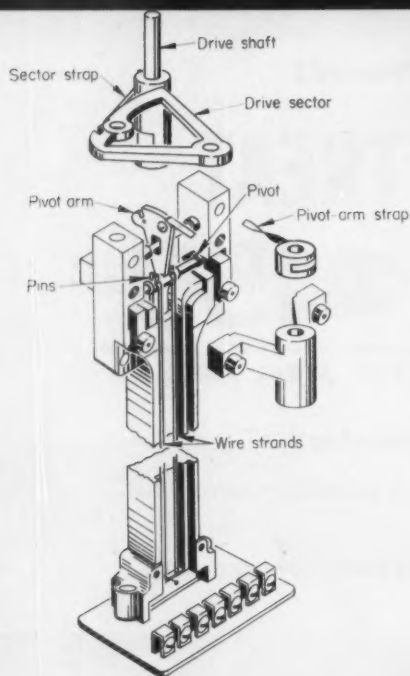
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Available from your Steel Service Center

Circle 407 on Page 19



Strain-Gage Rebalancer Bypasses Slidewire Faults

PHILADELPHIA — Wear, contact bounce, and limited resolution—long-recognized faults in potentiometer slidewires—have been eliminated by a new approach to self-balancing potentiometer design. Brown Instrument Div., Minneapolis-Honeywell Regulator Co., has substituted an electromechanical strain gage for the often cranky slidewire. The unit, called Stranducer, is claimed to represent a "state-of-the-art breakthrough" which gives infinite resolution for the first time.

Forming the heart of a new ElectroniK 17 potentiometer line, which is scheduled for production next month, Stranducer (sketch and

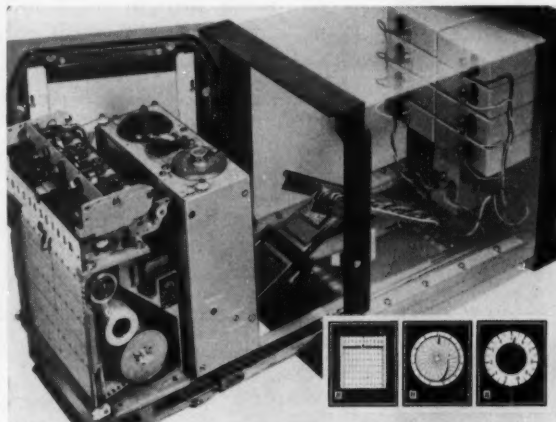
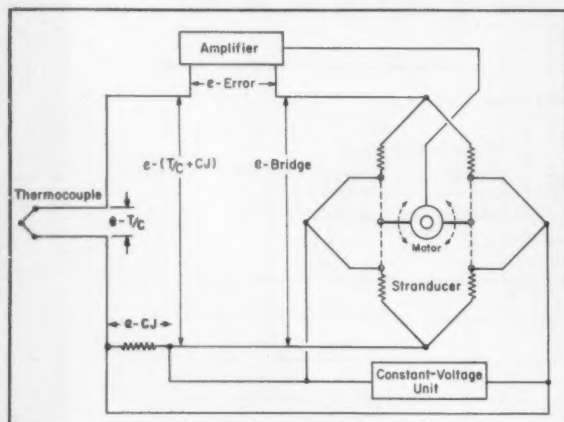
photo, above) varies the output potential of the measuring circuit to balance an input signal from a process-variable pickup. Four prestressed looped-wire strands, enclosed in an I-shaped frame, form the variable-resistance legs of the measuring circuit. Resistance varies with tension applied by a balancing servo motor. Rocking sectors, driven by thin straps for minimum friction, convert motor rotation to stretch in the wires.

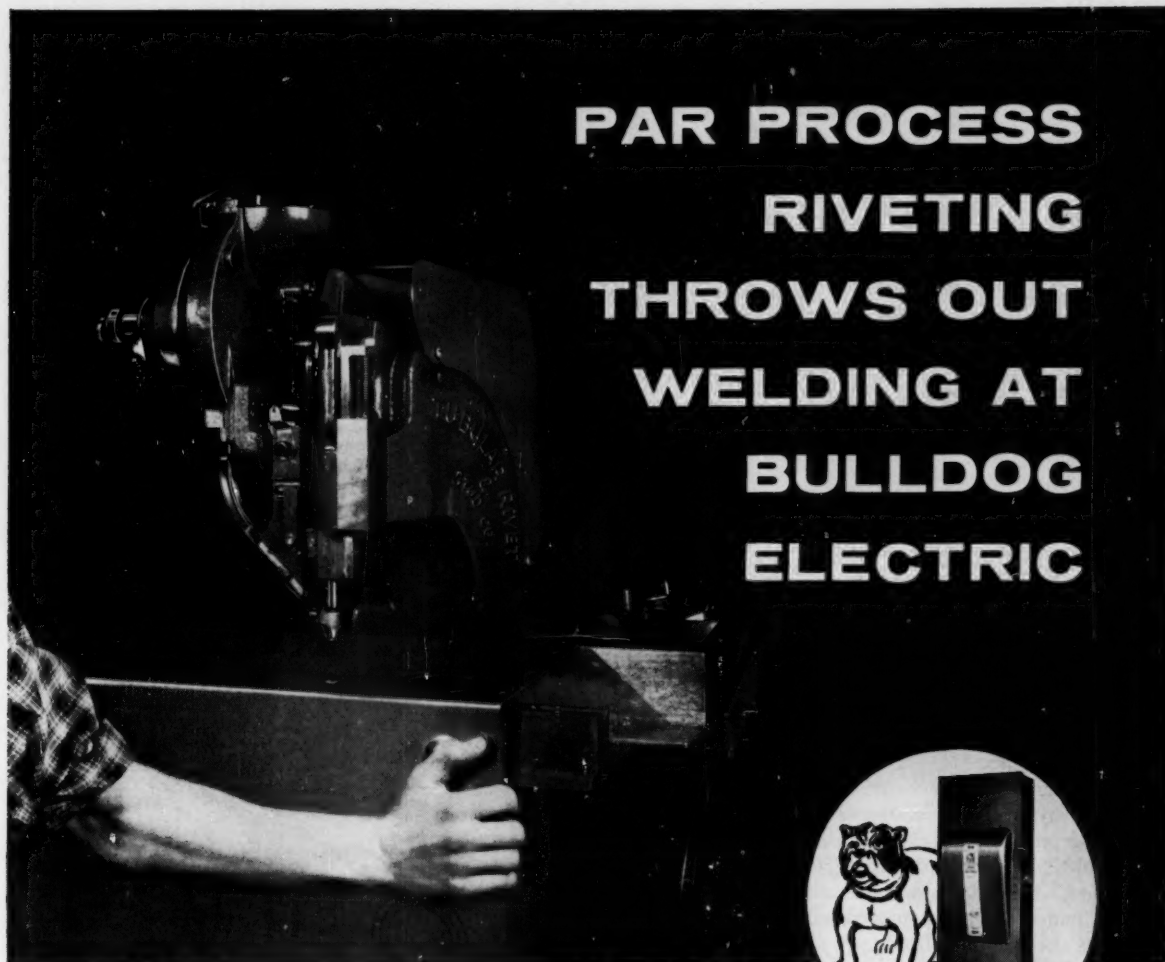
At zero position, bridge wires, fastened to the pivot arm of the Stranducer, have equal tension and resistance. As the pivot arm rocks, tension increases in two of the wires, decreases in the other two.

The bridge signal, working through the amplifier-motor servo loop (below, left) nulls out thermocouple (or other pickup) input voltage.

In addition to the rebalancing mechanism, the ElectroniK 17 line incorporates three other "firsts" in basic potentiometers: 1. Isolation of all critical components within an electrical shield; 2. One true reference-junction compensation for all thermocouples; 3. Transistorized plug-in control units

First models in the ElectroniK 17 line will be strip and circular-chart recorders and a circular indicator. Drive modules, containing measuring circuits and related components, are interchangeable.





PAR PROCESS RIVETING THROWS OUT WELDING AT BULLDOG ELECTRIC



Cuts Assembly Costs 65%

At Bulldog, TRS riveting replaced arc welding in assembling components of Vacu-Break® safety switch boxes... with an overall saving of 65% in assembly costs. Previously, twelve arc welds were used to secure the two spring stops and mounting rails of each switch box. Special fixtures were required to support parts in the box during welding, and after welding was completed the fixtures had to be dismantled. The entire operation was costly and time consuming.

Trained in the PAR Process approach to cost reduction, the TRS man saw that an automatic riveting set-up could be devised to simplify and speed the work. A roller support was designed to carry the weight of the box, and position the parts for twelve fast operations of a standard TRS automatic riveter. Other details of rivet design, tooling, and setting sequence were quickly solved with the aid of PAR Process know-how. Riveting produced an equally strong assembly and permitted visual inspection of fastenings to assure security.

FIND OUT what the PAR Process can save you. The PAR Process aims at lower costs and higher production rates. It starts with a sharp-eyed, production line search by your TRS man, for ways to eliminate or simplify and speed up steps in assembly. It is made effective by specially organized TRS procedures, backed by unique TRS developments in rivets and riveting machines.

The PAR Process may bring you better integration and fuller automation of assembly operations, or even a cost-cutting change in basic assembly method as with Bulldog. Ask for a check of your operations. Whether your assembly jobs are simple or complex, it can be worth dollars to you.

Don't Buy Riveting Machines until you learn how the TRS PAR process revolutionizes riveting



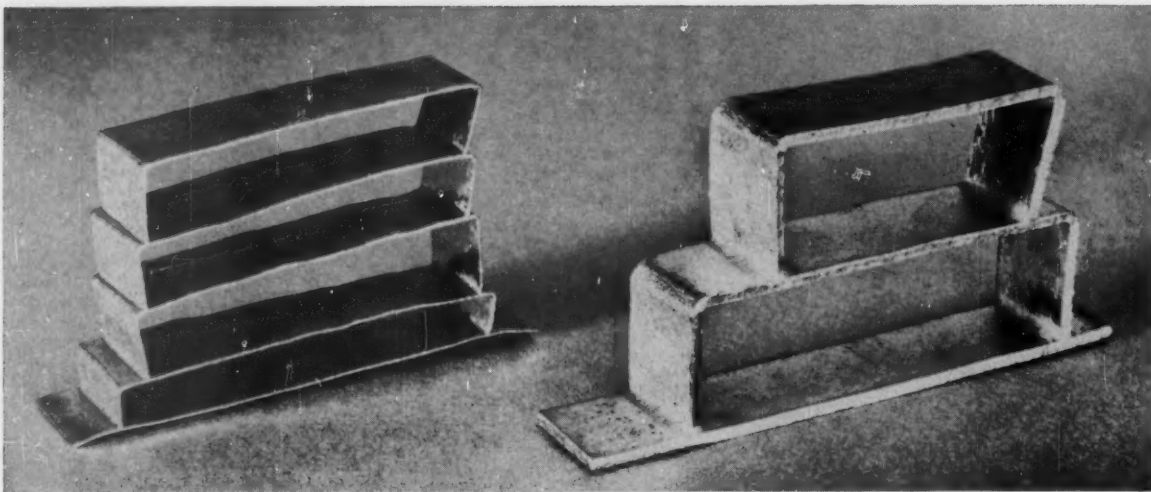
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See "Yellow Pages" for phone numbers.

If it's a Tubular Rivet TRS makes it... and Better





Before diffusion bonding, strip surfaces were coated with bonding agent; edges were not. Strip at left is 0.005-in.; at right it's 0.025-in.

Better Joints for Copper

A NEW method for joining copper parts may make soft solder obsolete. Diffusion bonding, a technique developed by Chase Brass and Copper Co., Waterbury, Conn., permits cost savings and easier production methods while improving product performance.

In the Chase process, two or more copper components can be joined with a homogeneous bond which is as strong as the base metal itself. A special coating on the metal surface diffuses into the parts to be joined, producing a bond without an interface. Joints made in this manner retain all the electrical and thermal-conductivity properties of copper.

Tests on diffusion-bonded joints show them to be markedly superior to soft-soldered joints in tensile, shear, and fatigue properties. Corrosion resistance is also excellent.

How It Works

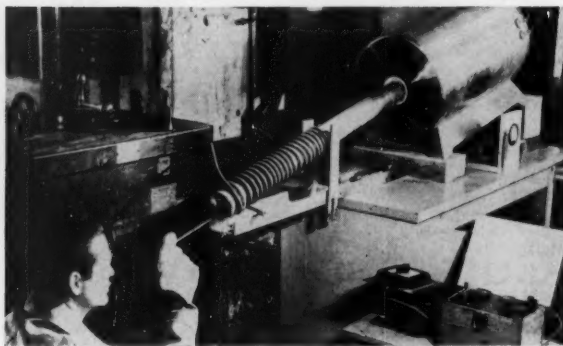
The coating can be applied before copper strip is rolled to finished gage, or it can be added directly to fabricated parts. Coated strip is annealed in a nonoxidizing atmosphere at moderate temperatures, then fabricated by the usual techniques of blanking, deep drawing, bending, etc. Fabrication does not adversely affect the coating.

Fabricated parts are first coated (if not formed from coated strip), then diffusion bonded at 1700-1800 F in a hydrogen or inert atmosphere for 5-15 min. The carrier coating volatilizes and dissipates in the furnace atmosphere. Complete diffusion, brazed, and combinations of diffused and brazed bonds are all possible.

In addition to the two direct coating methods, the company has also developed an indirect method: An insert of thin-gage strip, precoated on both sides, can be used to join any two components. The combination of different bonds and different coating techniques gives the process a high degree of flexibility and per-

mits a choice of ways to join parts, depending on the application.

Diffusion-bonded sample is removed from tube furnace. In the heating process, temperatures range from 1700 to 1800 F; bake time varies from 5 to 15 min, depending on size and gage of metal.




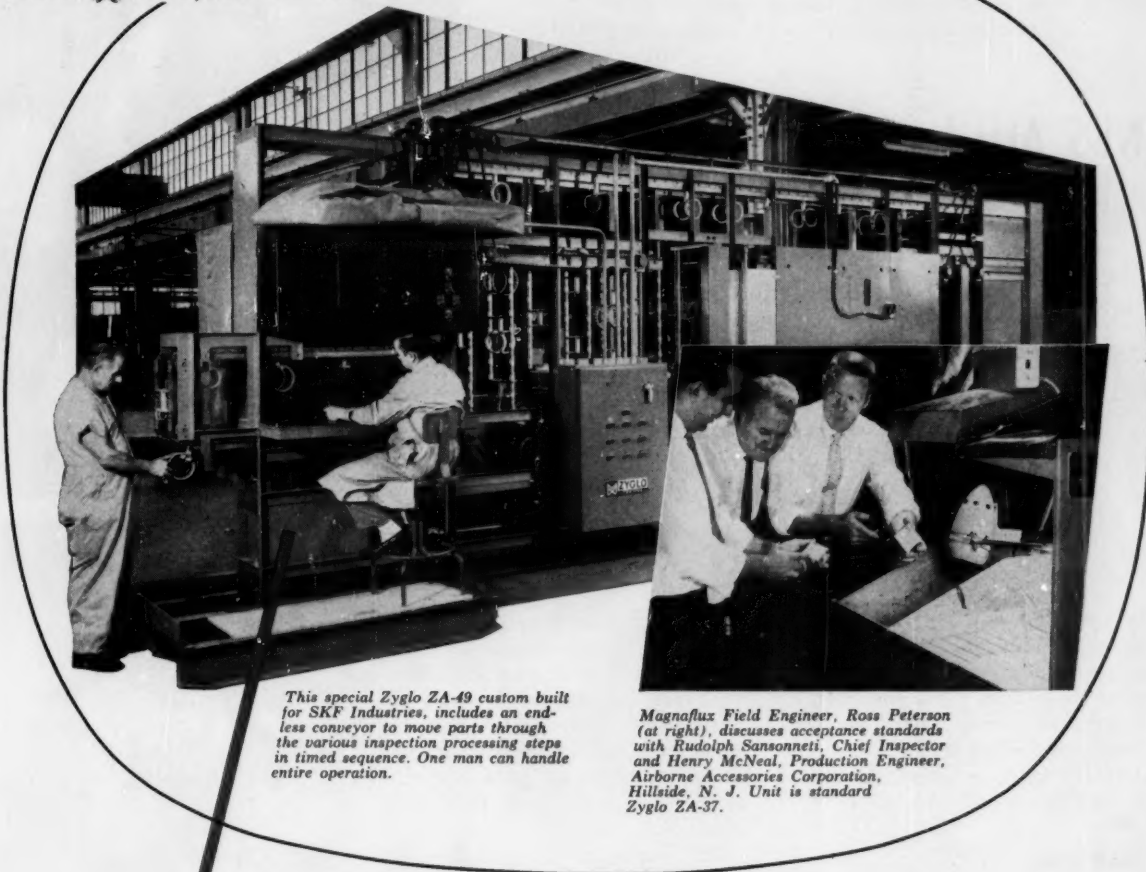
Limitations Exist

After exposure at diffusion-bonding temperature, the base metal is fully annealed—and has all the mechanical properties of annealed copper. However, many applications permit subsequent mechanical working of the metal, so the annealing is not a major drawback.

To date, true diffusion bonds have not been achieved with brass containing more than 5 per cent zinc. Joints can be obtained with brasses having even 30 per cent zinc, but these joints show a separate phase at the bond line (a characteristic of brazed joints).

Although all problems have not yet been solved, the diffusion-bonding technique is expected to find wide application. Because it simplifies the joining of materials, the technique should automate many operations which are now manual. According to Chase spokesmen, the process will be particularly useful where joints must be vacuum tight and capable of operating at high temperature.

Another  Test System at work...



This special Zyglo ZA-49 custom built for SKF Industries, includes an end-less conveyor to move parts through the various inspection processing steps in timed sequence. One man can handle entire operation.

Magnaflux Field Engineer, Ross Peterson (at right), discusses acceptance standards with Rudolph Sansonetti, Chief Inspector and Henry McNeal, Production Engineer, Airborne Accessories Corporation, Hillside, N. J. Unit is standard Zyglo ZA-37.

You Save Money Finding Cracks with ZYGLO—Large or Small

Fluorescent Penetrant Test for Nonmagnetic Materials

The big machine above is a specialized, automated Zyglo System with which one man tests up to 375 non-ferrous bearing cages per hour for cracks, porosity, or leaks. It includes complete conveyORIZED handling and programmed processing, custom engineered and built by Magnaflux. Parts tested range from $\frac{3}{4}$ " I.D. to 10" O.D.

The inset shows a hand-operated Zyglo ZA-37 used to test critical aircraft parts—from small screws in batches, up to 9-lb., 6" x 18" components.

Dozens of other Zyglo Units and Systems—larger, smaller and in between these examples—are available in standard, productionized-standard and specially engineered installations. Whether you need to test thousands of small parts per hour, a few large ones, or any combination, there's a Zyglo to meet your specs and savings objectives.

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MX Test Systems include MAGNETIC PARTICLE, FLUORESCENT PENETRANT, THERMOGRAPHIC, EDDY CURRENT, ULTRASONIC, STRESS ANALYSIS, RADIOGRAPHIC TESTING, DYE PENETRANT & MAGNETIC FIELD

Tantalum-tube, high-temperature furnace is used by NBS to calibrate refractory-metal thermocouples at temperatures in excess of 2000 C. Lack of standards for ultra-high-temperature measurement is a critical aerospace problem.

NBS Attacks Measurement Barriers

A co-operative effort by National Bureau of Standards and the aerospace industry is aimed at solving another problem in miniaturization

WASHINGTON — Members of the Aerospace Industries Association and representatives of NBS have met eight times during the past several months to discuss what they call "the measurement pinch."

Here's what, or where, the pinch is, and plans for relieving it:

Small Holes . . .

Miniaturization of extremely sophisticated mechanical components has resulted in a rather unsophisticated but vital problem area. Hole sizes have been reduced to the point where NBS calibration facilities are inadequate.

The hole problem is well illustrated in the production of inertial guidance systems. One industry representative claimed that if measuring techniques were available to permit holding the tolerances on bores and bearings to 10 mu in., the cost of a large-quantity production item could be reduced from \$950 to \$250. In the case of another item, inadequate hole-measuring techniques require the construction of three \$25,000 units for every good one produced.

To beat this problem, industry representatives are inclined to look to NBS for brand-new standards and techniques. They feel that time-honored procedures cannot provide the ultra-precise gaging which will permit mass production.

Similar handicaps also exist in measuring surface finish. Existing standards and techniques are often inadequate for effective screening of miniaturized components prior to assembly. Trial-and-error methods of finding defective parts are extremely costly in both time and money.

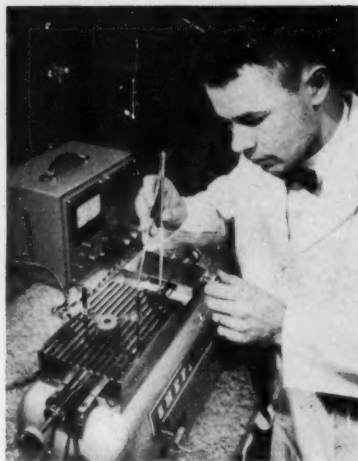
NBS has responded again, by initiating a calibration service for physical roughness standards, although the available accuracy, at first, will probably not meet all needs.

. . . and Gears

Limitations in the use of master gears as standards are recognized by both industry and NBS, but at present this is apparently the only technique available for small gears. Industry representatives urged that NBS acquire the facility to provide small-gear calibration service, and simultaneously organize a strong research program to develop better methods for standardizing gear measurements.

Temperature (High and Low)

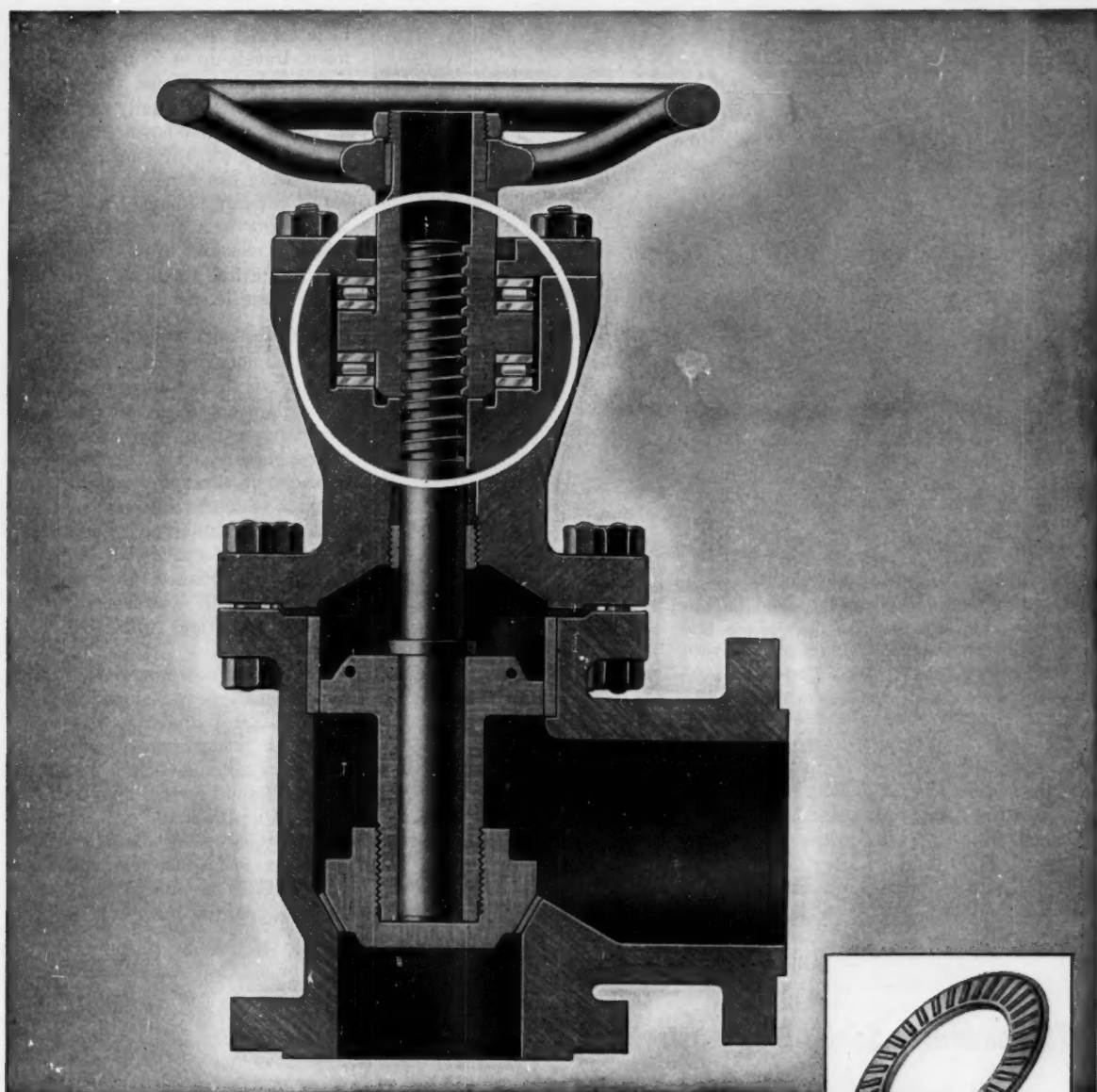
Substantial help in solving temperature problems will be provided by two new services expected to be available from the Bureau by July, 1961: Calibration services for germanium resistance thermometers in the cryogenic regions and for very-high-temperature thermocouples.



ID of holes as small as 0.017 in. in diameter are measured at NBS with commercial apparatus. Accuracy is within "a few millionths of an inch," but better techniques are needed.



Standard for surface finish (on anvil, left) has regularly spaced grooves of uniform depth. Insuring reliable gyroscope performance is a typical problem related to measurement of surface-finish characteristics.



*Compact valve design, easier operation
with Torrington Needle Thrust Bearings*

High thrust capacity, thin cross section and low unit cost have made Torrington Needle Thrust Bearings a natural choice for top valve performance. With Torrington Needle Thrust Bearings, only a fraction of the normal closing effort is needed. This puts less strain on the valve... means smoother, more reliable operation. Lifetime pregreasing insures peak efficiency over years of extra service life.

Torrington Needle Thrust Bearings are exceptionally compact. They provide an assembled height far less than any other type of thrust bearing. They may be run directly on adjacent hardened and ground surfaces, or, as shown above, on standard Torrington thrust races.

If you make gate valves, globe valves, angle valves—in fact, any valve closed on a threaded stem—you'll find it pays to investigate the top efficiency of Torrington Needle Thrust Bearings. Call or write Torrington—maker of every basic type of anti-friction bearing.



Torrington Needle Thrust Bearing



Torrington Thrust Race

progress through precision

TORRINGTON BEARINGS

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Indiana

XM-521 — An Unsinkable Truck



Equipped with an air-cooled engine and propellers for water movement, Army's new XM-521 experimental truck can't be sunk. Polyurethane foam (in wheel-well sponsons) and aluminum-honeycomb body panels keep the vehicle afloat even when it's completely filled with water or riddled with bullet holes. The truck, developed by Whirlpool Corp., can safely enter the water from 4-ft banks or 60 per cent slopes.

EVANSVILLE, IND.—Honeycomb aluminum and polyurethane foam have provided the Army with a new kind of truck. Able to "swim" while carrying a 5000-lb load, the new XM-521 vehicle meets the need for absolute mobility. It is a light-

weight compact cargo carrier that can be flown in and dropped by parachute. Intended to travel on inland waters, it can also traverse rough, cross-country terrain.

Developed by Evansville Defense Div., Whirlpool Corp., the test ve-

hicle carries 16 men with equipment, travels up to 55 mph on land and 5.2 mph in water. It can enter the water at virtually any speed, travelling down 60 per cent slopes or dropping off 4-ft banks. Because the vehicle can completely fill with water without sinking, it's designed with a short rear overhang that permits the rear end to dip under water for extra traction when the truck starts its climb up a bank.

From Airplanes and Refrigerators

Development of honeycomb panels for trucks, according to Whirlpool engineers, is an outgrowth of experience gained with bonded aircraft structures. Honeycomb structures are 16 times as strong as equal weights of solid steel and ten times as strong as aluminum. Each panel is made up as a sandwich of aluminum sheets bonded to a core of hexagonal cells. The cores are 97 per cent air and three per cent metal.

Probably a new material for truck construction, polyurethane used in the XM-521 is similar to that which insulates refrigerators. Foamed in place in the vehicle's sponsons, polyurethane provides buoyancy because of its closed air cells. In addition, it's so strong that gas tanks, batteries, and other equipment are imbedded in it without hangars or other supporting members.

OTS Condenses Soviet-Bloc Abstract List

WASHINGTON—Reviews of Russian and Chinese technical articles are again available. Office of Technical Services, the Federal Government's clearing house for translations and reports on Government-sponsored research, plans to abstract articles in six subject areas, publish the abstracts monthly, and sell them on a subscription basis. The service will start in late January.

Streamlined Service

The new service replaces one that was discontinued last June. The older version, which consisted of cover-to-cover abstracts of some 100 Russian technical journals, was stopped because of the small number of subscribers. But the new program, says John C. Green, OTS director, is streamlined to offer sub-

scribers more meat for less reading. "We are now going to group abstracts of selected articles (from a much larger number of publications) into individual packages."

A prepublication survey indicates that this service will be a more usable one for the public. There have already been more than 300 tentative subscriptions for each of the six subject series covered. The survey pointed out which areas of Soviet-Bloc literature were of interest to the scientific community. Only high-interest areas will be abstracted.

From Physics to Misc.

Subscriptions to the six new series will be accepted for a six-month period. The six series and estimated number of abstracts per month include:

- Physics, Geophysics, Astrophysics, Astronomy, Astronautics, and Applied Mathematics (225).
- Chemistry, Chemicals, and Chemical Products (150).
- Metallurgy, Metals, Metal Products, and Nonmetallic Minerals (450).
- Engineering, Machinery and Equipment (225).
- Communications, Transportation, Navigation, Electrical and Electronic Equipment, Systems, and Devices (225).
- General Science and Miscellaneous (225).

Subscriptions are now being accepted by Office of Technical Services, Business and Defense Services Administration, U.S. Dept. of Commerce, Washington 25, D. C.

Topics

Getting unstuck from snow can be done without even getting out of the car—if the car is equipped with a new accessory. This device spreads sand in front of the rear wheels when a dashboard button is pushed. It is also recommended by its maker for assuring fast stops on icy roads.

• • •

First all-electric shaver, patented by Harry J. Hobbs, uses no blades. Mr. Hobbs' invention has tiny fingers, spaced 0.003 to 0.005 in. apart on the shaving head. Fitting in slots between these fingers, whiskers are dispatched by electric current sent through the two sides of the [shaving] head. A guard protects the user from shocks, and the inventor gives the assurance that even though the hair is "presumably burned off" by the electric current, there is "little or no heating up of the electrodes, the guard, or the face itself."

• • •

Polluted progress: Exhaust from the take-off of one commercial jet liner has been estimated to create as much air pollution as 6850 automobiles.

• • •

No noise at all should accompany the disarmament of unexploded bombs by a new "ultrasonic-can-opener" technique being studied by Raytheon Co. engineers. Ultrasonics may provide a way to cut into steel-encased bombs without generating excessive heat.

• • •

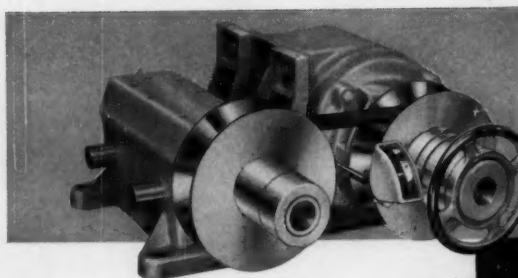
The "Skaters' Waltz" may be considered pretty much of a drag by the roller-rink habitue using new motorized skates. Skate wheels of the \$250 outfit are powered by a 1-hp motor which the wearer straps to his back. The skates normally travel at a top speed of 17 mph; for racing against go-karts, they have been souped up to 40 mph.

• • •

Plastic pedaling: The frame of a new U. S.-built bicycle will be made of reinforced plastic instead of steel.

• • •

Wash-and-wear hats for the whole family are being turned out at the rate of one every 10 seconds at an automated British hattery. The first models—uncrushable, shape-retaining, and economical—are molded from synthetic fibers that resemble fine straws. Future plans call for development of an imitation felt.

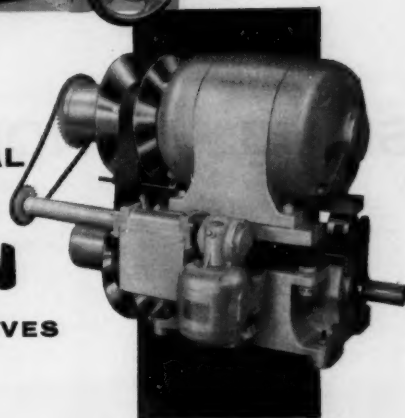


NOW...

**BOTH HORIZONTAL
AND VERTICAL**

LEWELLEN

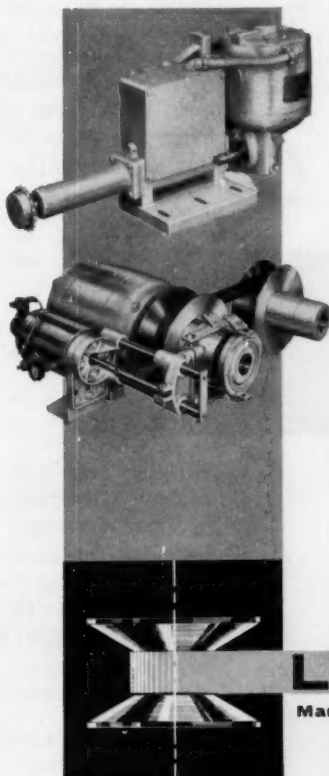
VARIABLE SPEED DRIVES



Here are both horizontal and vertical variable speed drives. Each is an assembly of standard components—a motor, LEWELLEN Combination Pulleys, and the horizontal or vertical Countershaft.

The horizontal drive assembles either right hand or left hand. Both the horizontal and vertical drives mount at floor or ceiling.

Accessories may include the mechanical Indicator, or the Electric Tachometer and Electric Remote Control, as shown.



A bridge circuit controller dials all speed settings by equipping the Electric Control unit with a potentiometer.

Or, the Pneumatic Regulator automates the operation by connecting with process instruments.

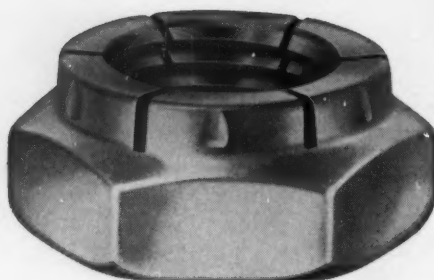
Here are accessories for readily using the flexibility of variable speeds—for using LEWELLEN Variable Speed Drives as you choose.

Write for Catalog 70

LEWELLEN

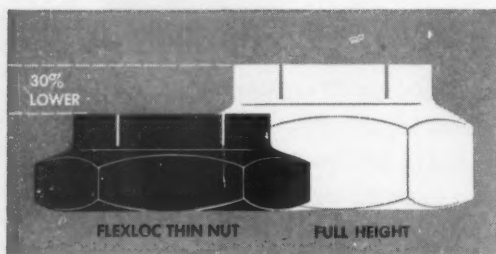
Manufacturing Company, Columbus, Indiana

Distributors in all Industrial Areas



SMALL WONDER: **FLEXLOC** THIN NUT

30% lower and lighter, yet still stays put for keeps!



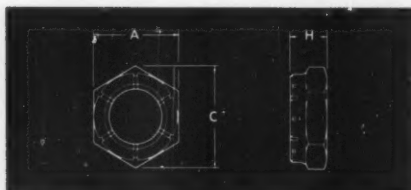
Frequently you need a smaller, lighter locknut, yet you can't afford to sacrifice one whit of holding power. That's where self-locking FLEXLOC thin nuts come in.

Since they are 30% lower than full height locknuts of the same diameter, FLEXLOC thin nuts allow you to design more compact bolted joints. They often fit into space where clearance is insufficient for standard height nuts. Also, thanks to minimum projection, they improve appearance and increase safety.

And FLEXLOC thin nuts save precious weight—they themselves are 30% lighter and you save additional weight by using shorter bolts or studs.

What about reliability? FLEXLOC thin nuts won't budge, even in the face of impact or vibration. This is because every thread, including those in the locking section, carries its full share of the tensile load.

FLEXLOC thin nuts also . . .



- Simplify design—1-piece fasteners (no auxiliary locking elements required)
- Save production time—fewer turns needed to seat
- Lock without seating—serve as stopnuts as well as locknuts
- Can be readily removed and repeatedly reused
- Available in stainless as well as alloy steel

FLEXLOC thin nuts come in sizes from #6 to 1½ in. For complete information, see your authorized SPS distributor or write Standard Pressed Steel Co.—manufacturers of precision threaded fasteners and allied products in many metals, including titanium—for Bulletin 2339. INDUSTRIAL FASTENER Division, SPS, JENKINTOWN 18, PENNSYLVANIA.

SPS

where reliability replaces probability

Reader Information Service

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409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
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418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
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405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
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417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870

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Page No.

Title of Article

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME

TITLE

COMPANY

PRODUCT MANUFACTURED

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CITY

ZONE

STATE

Do not use this card after March 19, 1961

MACHINE DESIGN **Jan. 19, 1961**

Circle item number for information on products
advertised or described or copies of literature.

241	421	451	481	511	541	571	601	631	661	691	721	751	781	811	841
242	422	452	482	512	542	572	602	632	662	692	722	752	782	812	842
243	423	453	483	513	543	573	603	633	663	693	723	753	783	813	843
244	424	454	484	514	544	574	604	634	664	694	724	754	784	814	844
245	425	455	485	515	545	575	605	635	665	695	725	755	785	815	845
246	426	456	486	516	546	576	606	636	666	696	726	756	786	816	846
247	427	457	487	517	547	577	607	637	667	697	727	757	787	817	847
248	428	458	488	518	548	578	608	638	668	698	728	758	788	818	848
249	429	459	489	519	549	579	609	639	669	699	729	759	789	819	849
250	430	460	490	520	550	580	610	640	670	700	730	760	790	820	850
401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
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420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870

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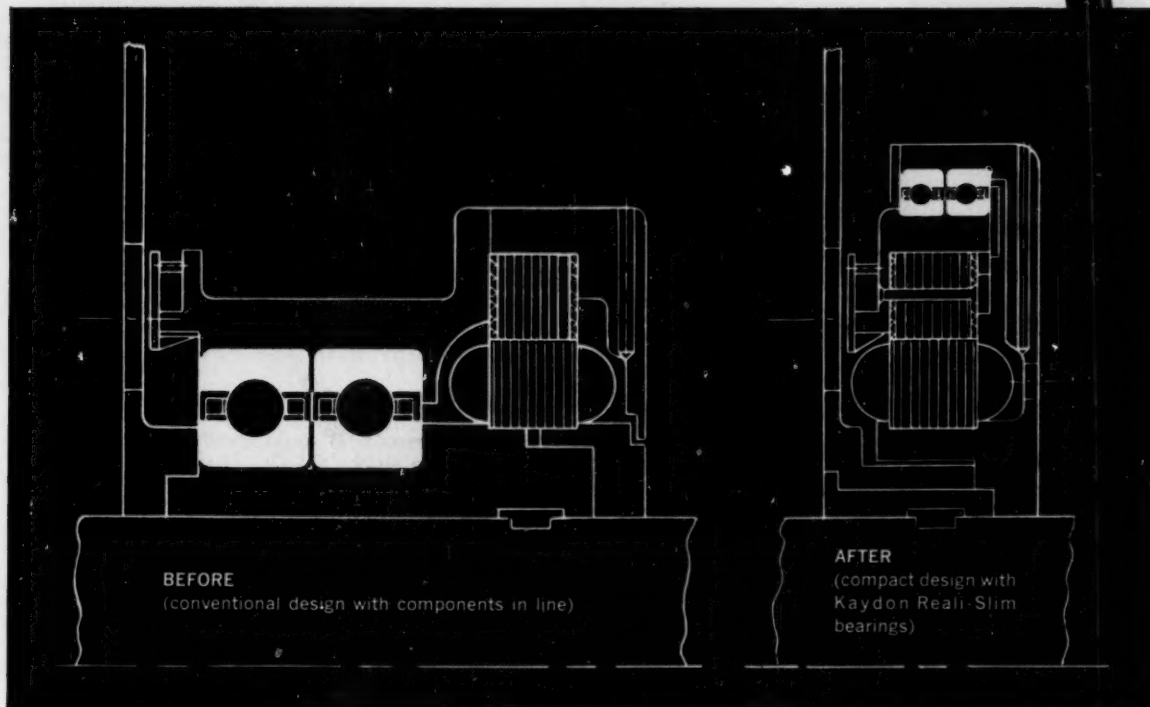
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*Don't let in-line design get
in the way of a compact product...*

"NEST" COMPONENTS INSIDE THE BEARING BORE



Motor assembly redesign shown above is typical of the way Kaydon Reali-Slim bearings save space, reduce weight, cut costs!

Kaydon thin-section Reali-Slim bearings provide valuable component space inside the bearing bore. And use of a hollow shaft permits utilizing this space for control rods, linkages, collets, counter-rotating shafts, clutches and brakes, to name a few possibilities.

With Reali-Slim bearings, you save weight and space in both bearing and housing, reducing costs for materials, shipping, storage and handling.

And large-bore Reali-Slim bearings give closer support to the outer edge of rotating parts, instead of the center only, which gives more rigidity and accuracy for moment loads.

Stocked in 90 sizes! These Kaydon Reali-Slim Type CP bearings have Conrad deep-groove, ball-radial construction and new bronze, one-piece snap-over separator in 4" to 12" bore— $\frac{1}{4}$ " to 1" width and cross section. Kaydon's volume production cuts prices up to 76%, depending on size.

Contact Kaydon now. Have the Kaydon sales engineer or distributor salesman in your area discuss Reali-Slim bearing applications for your products. Or write for free, fact-full "CP" bearing bulletin—with prices.

Shown here
is an actual
size KA-100-CP
bearing, with
9 $\frac{1}{2}$ " bore,
 $\frac{1}{4}$ " cross section
and $\frac{1}{4}$ " width

THE KAYDON ENGINEERING CORP.
MUSKEGON, MICHIGAN

*All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller
Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings*

a good manager is hard to find

Availability of high-paying jobs for executives of small and medium-size companies continues on the same level as a year ago, according to a survey by Executive Manpower Corp. Reports from 178 companies with average annual sales of \$11.5 million show a need for slightly more than one executive per firm for jobs paying \$10,000 to \$75,000. Greatest need is for sales executives (36.6 per cent of the companies need them); a close second in demand (31.3 per cent) are men suitable for engineering-management positions.

automating the boss

By plugging into central computer memory systems, executives could speed up decision making by a factor of ten, according to Dr. John Manglesdorf, Lockheed human-factors specialist. "Today's executive spends a phenomenal amount of time waiting for information. There is a very real danger that large, complicated organizations will bog down completely in a few years." Except for the telephone, Manglesdorf adds, decision makers get little more mechanical help "than did their counterparts among the ancient Egyptians."

short-term instrumentation

Abrupt cancellation of government contracts is now less of a worry for small companies: Expensive instruments necessary for the work no longer need sit around idle. A new rental plan developed by National Equipment Rental Ltd., New York, allows lease of apparatus for the undetermined period of contract life. Although normal leases run from three to ten years, equipment can now be obtained for six months or less.

nuclear space power—one step closer

Prototype of the first reactor designed for outer space completed its first year of ground tests last month. Engineers now have enough performance data to draw up the final design. SNAP Experimental Reactor (the prototype) weighs 250 lb, is about the size of a five-gallon can. Developed by Atomics International, the device is fueled with enriched uranium to produce 50 kw of heat at a 1200-F coolant-outlet temperature. According to the Air Force, the reactor has operated for more hours at this temperature than any other reactor in the world.

cut-rate fuel injection

A "foolproof, self-servicing" gasoline injector, small and light enough to replace an auto carburetor and costing only about \$20 extra, is announced by Simms Motor Units Ltd. of London. Advantages claimed by this "baby" injection pump include more rapid acceleration, greater maximum speed, a smoother-running engine, fuel economy, and reduced engine wear.

down-to-earth solar energy

The sun's energy is becoming a serious blue-sky candidate for chores such as house heating, thanks to its successful use in space vehicles. John I. Yellott, president, Yellott Engineering Associates Inc., Phoenix, points out that in the pre-satellite era, "solar-energy applications were the province of a few university scientists. Today, every airframe manufacturer has a corps of solar specialists, augmented by engineers who must design practical apparatus and make it work." Mr. Yellott feels that technological advances resulting from space research will make solar radiation economically feasible for earth-bound applications.

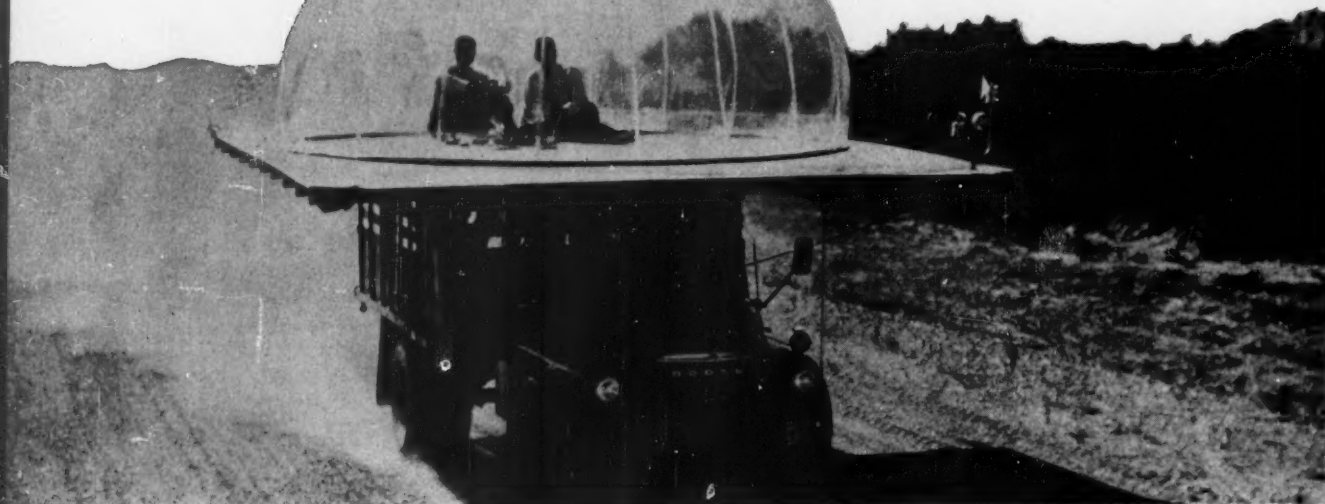
battering the batteries

To keep million-dollar satellites from fizzling because of \$150 batteries, Cook Electric Co. is opening a new testing center. Company engineers, working in something like a "consumer's research" operation, will test batteries to failure, then hold post-mortems to find out why they went bad. The program, sponsored by Wright Air Development Division, is expected to result in new information on battery life and performance. Test data will be widely distributed.

speed-up for supersonic data

Flight-test data can be analyzed in hours with a new electronic system used on the Republic F-105D supersonic fighter-bomber. Heart of the system, developed by Epsco Inc., is an airborne electronic converter that samples performance data in analog and digital forms and records them on magnetic tape. After the flight, the tape is fed into equipment that translates and prepares the information for an IBM 704. Analysis of information acquired on a ten-second aerial maneuver—now ready in two hours—previously required 230 man-hours.

Schjeldome, an air-supported structure of Mylar polyester film, was tested on this "moving wind tunnel." Purpose of the test was to prove the structure (developed by G. T. Schjeldahl Co.) can withstand winds of hurricane speed.



Report On Film

WILLIAM H. WOOD

Film Dept.
E. I. du Pont de Nemours and Co.
Wilmington, Del.

THE period of cautious testing of thin-films is over. Design uses have doubled in the past five years, will double again by 1970.

Until a few years ago, thin plastics were considered almost exclusively as packaging materials. Wider use in engineered products came with development of new films with properties tailored to the designer's needs. Offering a range of chemical, physical, and electrical properties, this family of materials made possible new approaches to engineering problems, improved product performance, and reduced manufacturing costs.

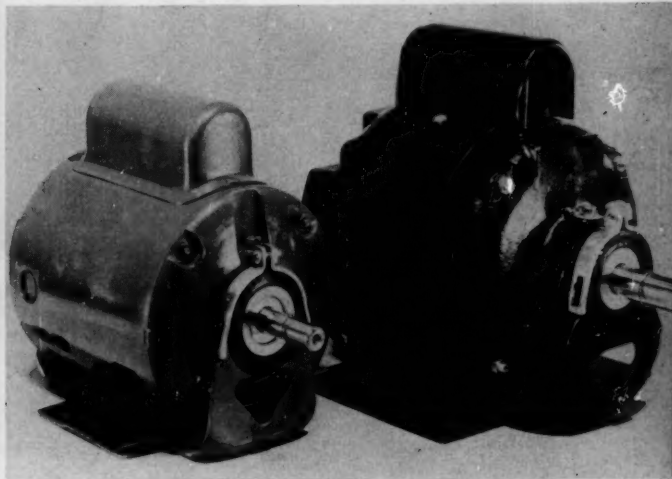
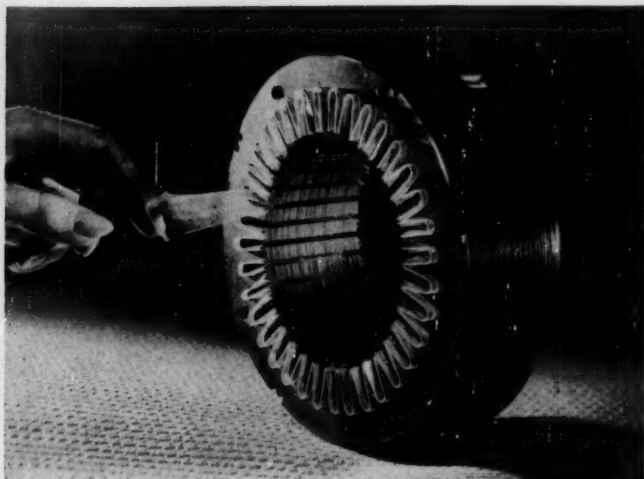
Design advances in electric motors made over the past few years can be traced, in part, to the development of the first polyester film created specifically as an engineering material. Mylar, a film that is insensitive to moisture and has high physical and dielectric strength, permitted reduction of slot dimensions by half. Redesigned motors, using 7½-mil Mylar instead of 15-mil paper, perform better than older models, yet require less copper and steel. Weights and volumes are about half what they were previously.

How creative designers are
exploiting thin-film plastics
for improved product performance

flexible strip conductors



Used for slot lining and phase insulation in electric motors, polyester film was the key to redesign of this appliance motor. It's 40 per cent smaller and 33 per cent lighter than its predecessor. Capacitors can also be reduced in size: The two on the left (insulated with Mylar) contrast sharply with older versions on the right. Later models (which use plastic rather than metal encapsulation) offer even more striking contrasts.



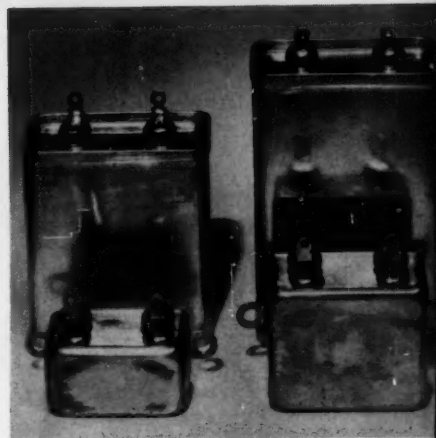
Motor improvements made possible by thin-film insulation haven't yet been fully exploited. To boost performance at extreme temperatures (up to 400 F) and in unusual chemical atmospheres, scientists are evaluating formed coils insulated with the new Teflon FEP-fluorocarbon film. Besides high-temperature stability, this new pinhole-free inert can be heat sealed to itself, allowing construction of extremely compact packages with excellent insulation characteristics.

Teflon FEP film, first produced in commercial batches in late 1959, shares all the advantages of the older TFE-fluorocarbon resins, but differs in melt-flow properties. A

new process produces uniform, pinhole-free films from FEP resins. These can be produced in thicknesses from 0.5 to 40 mils or more.

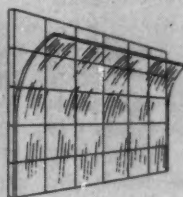
Seals for Earth or Space

Bonded by heat to Teflon TFE resins, FEP film is finding work as a penetration shield in seals, gaskets, and diaphragms. The pore-free surface provides a positive barrier to fluids. In the older TFE laminations, microvoids allowed fluid penetration through the surface. Seals laminated from mineral fibers and TFE resins provide an excellent balance of rigidity, flexibility, smooth finish, and nonsticking characteristics.

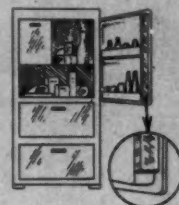


Missile research has resulted in Teflon FEP containers and diaphragms that allow long-term ambient-temperature storage of exotic liquid propellants. According to low-temperature specialists, of all the

protective coatings

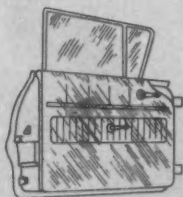


insulation pouches

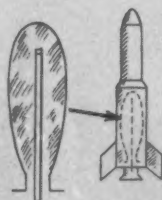




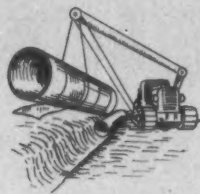
heat reflectors



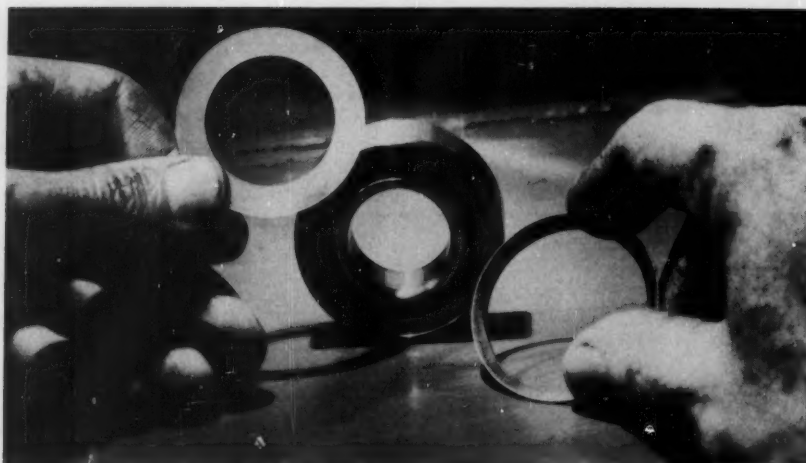
decorative trim



fuel bladders



moisture seals



Thin-film ball-bearing seals keep lubricants in while keeping contaminants out. Ten-mil films maintain uniform contact while allowing low-seal torques, eliminate failures due to seal embrittlement (caused by lubricants sometimes used in lawn mowers and other small power-driven tools).

flexible materials available, only Teflon films meet necessary requirements. The problem of permeability of Teflon to liquid rocket fuels was solved by sandwiching aluminum foil between two layers of the film. Now being considered for fuel bladders in missiles and ground storage tanks, Teflon laminations will be quite capable of containing even such troublesome fuels and oxidizers as Aerozine-50 and nitrogen tetroxide.

Ultracold No Problem

Low-temperature toughness of bladder materials has always been a problem in handling and storing cryogenic fuels. Newest and most-promising answer is a flexible structure of tetrafluoroethylene fabric and FEP film. The lamination is strong, tough, chemically inert, and pore free. In addition, it has an excellent low-temperature flex life.

This material and one other candidate—a lamination of asbestos fabric and FEP film—are now being considered as clothing for cryogenic-fuel handlers.

More Components—Less Space

One of the major design headaches accompanying development of jet aircraft and ballistic missiles was the need to squeeze electronic circuits into ever-smaller spaces. The problem was twofold: Circuits were

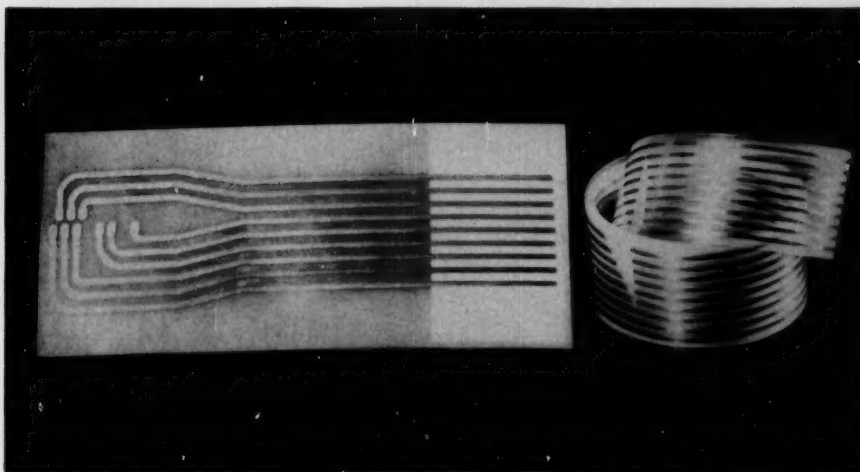
bulky; cramming circuits into un-ventilated spaces created heat breakdowns.

Once the transistor replaced the tube, capacitors became the largest circuit items. Holding back development of small capacitors was thickness of the insulating film, usually impregnated paper. The component designer could reduce insulation thickness only at the sacrifice of capacitor life.

Mylar polyester film gave capacitor manufacturers their golden opportunity. For equivalent voltage capability, insulation thickness could be almost halved by replacing paper with Mylar.

Subsequently, the ultimate in capacitor miniaturization was achieved by substituting metallized Mylar for the traditional film-foil construction. This was accomplished by vacuum depositing an ultra-thin layer of aluminum directly on the film. Use of this single-film technique allowed an almost fourfold reduction in capacitor diameter.

During the early space age, circuit designers were faced with rising temperature levels. They needed a material that would provide higher insulation (at least one or two orders of magnitude higher than paper). Demand for capacitor performance at temperatures ranging from 300 to 480 F necessitated use of a different film. At this heat level,



As a base for printed circuits, Teflon FEP film withstands much higher temperatures and more severe chemical environments than traditional materials. Top layer of film is pulled back and stripped off (lighter region) in the area where connectors will be attached.

Mylar is no longer functional, so the solution to the problem had to await development of Teflon TFE fluorocarbon resins.

Early films of Teflon were expensive and showed pinholes, but they did provide adequate insulation resistance and dielectric strength. The newer Teflon FEP film permits further developments in this area because of its lower price and freedom from pinholes. Heat sealability is also an important factor.

Backed By Adhesives

Versatility of Teflon FEP fluorocarbon films improved considerably with development of a new type (announced last October) that can be cemented on one side with common adhesives. Data show the film can be anchored to a variety of engineering materials as a nonstick or protective surface. Applications include: Liners for tanks, cylinders, hose, and tubing; ice-release coatings; release cladding on heated or chilled processing rolls.

Backed by rubber adhesives, the film can be cemented over rubber and asbestos for chemically resistant diaphragms and seals. Other standard adhesives have been used to apply it to fabrics and to make several kinds of pressure-sensitive tapes.

Teslar, an extremely tough,

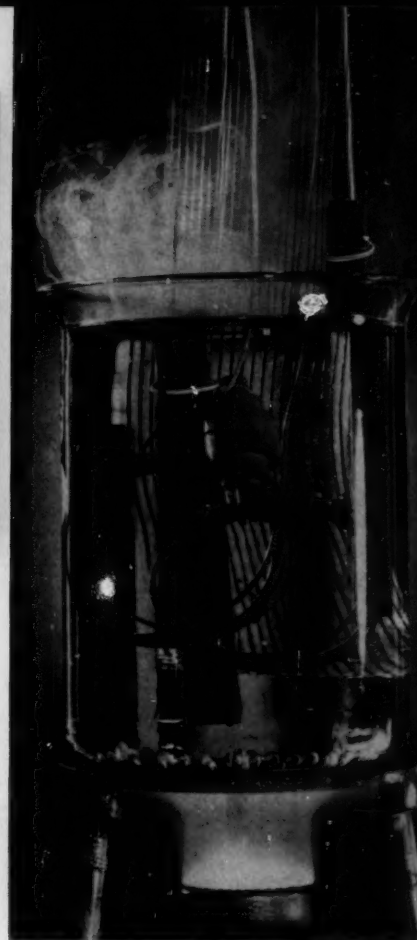
weatherable, and chemically resistant polyvinyl fluoride film now in limited production, is also available in an adhesive-backed form. Adhesive Teslar, announced within the last month, can be quickly and permanently bonded to a wide range of materials, providing weather-proof surfaces that will remain serviceable and maintenance free for up to 20 years.

Metallized for Good Looks

The "out of this world" use of metallized Mylar in the Echo satellite was well publicized. Few engineers, however, are aware of its many down-to-earth applications. The metallized film, either by itself or laminated to other plastic materials (particularly the vinyls), has found a myriad of uses replacing cast or die-cut metal for trim and accessories on appliances and other consumer goods.

These film-based materials, economical to use and easy to fabricate and apply, offer the designer a new range of colors, textures, and decorative effects. And, because of their thinness and flexibility, they may be applied to contoured surfaces with pressure-sensitive adhesives, instead of more costly metal-fastening devices.

Creative designers are combining the strength, abrasion-resistance, and nontarnishing properties of the films



Boiled in hot concentrated sulfuric acid, Teflon FEP-fluorocarbon film suffers no damage. Detailed laboratory tests show that the new plastic is unaffected after 120-hr exposure at 200 C, or after a week at 100 C in 30 per cent sulfuric acid.

with their dielectric strengths and high melting points. One decorative and functional example is a portable, three-panel radiant-heat screen. Designed as a room divider, this heater is a sandwich lamination of Mylar and an aluminum-foil printed circuit (applied to a rigid panel which radiates heat from its face). An embossed vinyl film is laminated over the heating element.

Laminations of Mylar with paper are finding applications which range from an automatic typewriter tape (with a service life several hundred times that of a paper tape) to washable and reusable corrugated fiberboard airline food containers.



ENGINEERING NEWS PICTURE REPORT

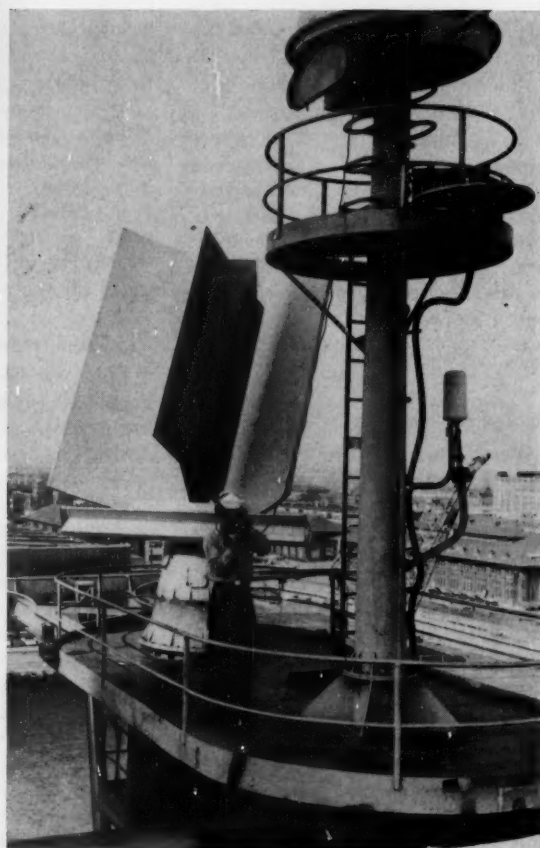
Five people and their luggage can travel over 1000 miles nonstop in Beech Aircraft's newest plane, the model 55 Baron. Powered by two 260-hp Continental fuel-injection engines, the Baron has a cruising speed of 216 mph. Top speed is 230 mph. The plane is licensed for both takeoff and landing at full gross weight of 4880 lb; useful load is 1920 lb.



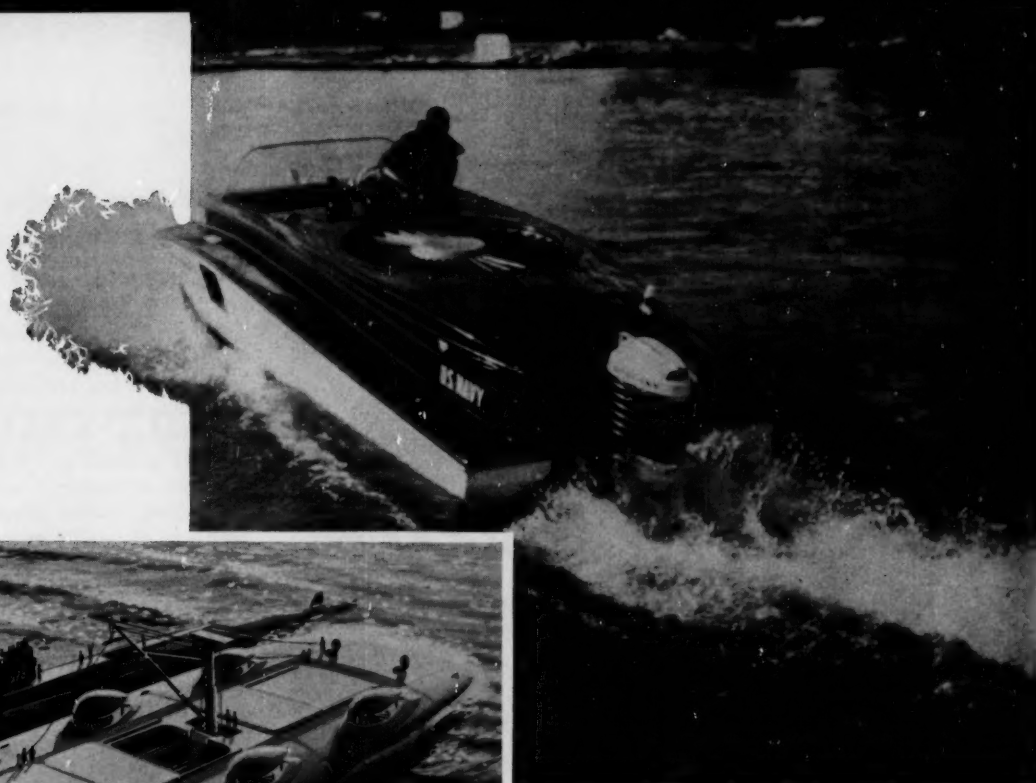
This is a computer-tutor, the first teaching system to use a digital computer. Designed by the System Development Corp., Santa Monica, Calif., the "teacher" has a Bendix G-15 computer programmed to respond to answers to multiple-choice questions. Punching the correct key on the electric typewriter brings the next question; punching the wrong one gives the student additional instruction in the form of remedial questions.



A new liquid silicone rubber has "gone on record" to demonstrate its accuracy of reproduction. Used to make a mold for a plastic phonograph record, it caught even the label imprint from the original master recording. The new silicone rubber, which vulcanizes at room temperature, was developed by the Silicone Products Dept. of General Electric Co.



Lightweight, single-antenna radar provides missile-armed cruisers and destroyers with three-dimensional target information. Frescan, developed by Hughes Aircraft Co. and the U. S. Navy, is the first seaborne electronic scanning radar to pinpoint range, bearing, and altitude of a target without the help of several antennas and heavy, mechanical gyro-stabilizing equipment.

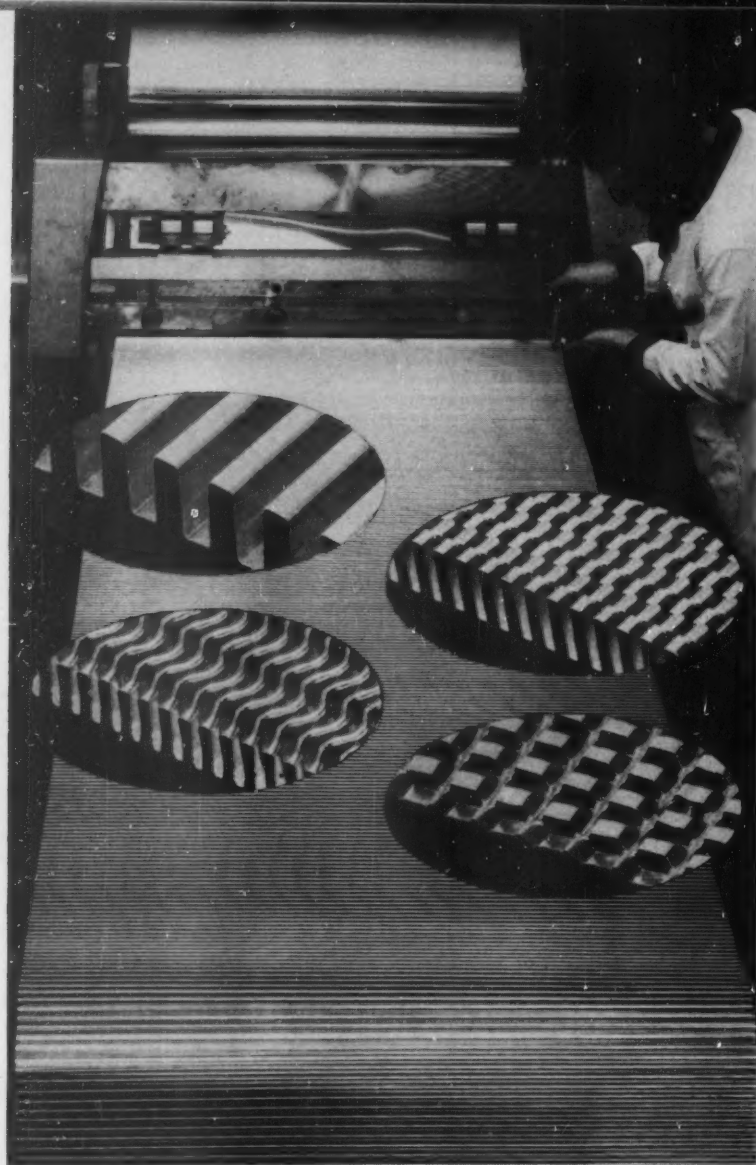


A boat that goes near the water, not through it, an 18-ft hydroskimmer has been built by Bell Aerosystems Co. for testing and evaluation by the Navy. The air cushion on which the craft rides is provided by a large fan; the outboard motor is for forward propulsion. High speed on comparatively low power makes a bigger hydroskimmer ideal for service such as bringing supplies to submarines, as shown in the drawing.



A little less is offered the carriage trade by two 1961 models: Shorter rear deck, by the Cadillac Town Sedan; a smaller back window, by the Imperial Le Baron. Except for its 7 in. shorter length, the Town Sedan's other dimensions are identical to Cadillac's Sedan de Ville. Chrysler's Le Baron differs from other Imperial models mainly in the rear roof line and window openings—its 802 sq in. back window is the smallest of any standard-size American car.





Folded-Metal Machine Opens New Applications For Corrugated Sheet

BUFFALO, N. Y.—Greater variety in corrugated sheet is offered by a new Twin Coach Co. machine that folds the metal into shape. According to the developer, folding instead of drawing corrugations bypasses such problems as pattern variations, size limitations, coarse tolerances, and high cost of tooling and set-up.

Key element in the machine is a cam action which moves forming dies in both horizontal and vertical planes. The model currently in use at Twin Coach takes stock in widths up to 36 in. and can handle several rolls of varying widths and patterns simultaneously, providing the total width remains within the 36-in. limit.

Corrugated patterns, formed to a 0.001-in. tolerance, can be further processed by embossing, shearing, bending, or scratching. Materials handled include aluminum, brass, copper, regular and stainless steel, as well as cardboard and plastics.

Continuous corrugation of coil stock in gages from 0.002 to 0.030 in. is performed with simultaneous perforating, off-setting, slotting, or lancing (left). Die costs range from \$800 to \$3500; die life is at least 1000 hr.

Diode Promises Jam-Free Microwaves

Varactor Detects, Amplifies 20,000-mc Signals

NEW YORK—A "smaller-than-buck-shot" diode that behaves like a variable capacitor has been awarded breakthrough status in microwave communications. The developer, Radio Corporation of America, lists three systems in which the new solid-state device—called a varactor—will make important contributions:

- Military and commercial microwave communications that are nearly invulnerable to enemy jamming.

- Extend-frequency radio bands (close to the infrared), making possible expanded point-to-point communications traffic.

- Low-cost, long-lived and compact microwave receivers for application in space vehicles, ballistic missiles, and radio telescopes.

When operating in an electronic circuit, varactor diodes take a microwave signal from the atmosphere or outer space and kick it up to a higher energy level by phasing in a "pump" signal generated by another

source in the circuit. The boosted signal, passed through several additional amplification stages, will then activate equipment such as speakers, radar scopes, or computers.

The RCA varactor diode, one of seven new types that operate within the 2000 to 20,000 megacycle range, was perfected by RCA's Advanced Development Laboratories. The devices are made of gallium arsenide.

Price to microwave equipment manufacturers runs from \$200 to \$700 each, depending upon the level of the diode's frequency response. This makes them "more precious than diamonds," says RCA.

NOW...

a new, low cost method to prevent rust and corrosion

CRC 3-36 eliminates corrosion by a dual action. First, by separating moisture from the metal surface; second, by sealing the surface against re-entry of moisture and corrosive atmospheres.

Check these benefits:

Easy to apply . . . either by spray, brush or immersion.

Affinity for metals . . . spreads quickly, penetrates and clings to grain boundaries, pores and cracks.

Economical . . . extremely low surface tension makes a little go a long way.

Need not be removed . . . will not affect subsequent manufacturing procedures, painting or plating.

In addition, this formula prevents intergranular corrosive action and insulates dissimilar metals to prevent electrolysis. It is equally effective on painted or plated surfaces which are inherently porous, preventing minute sub-surface corrosion which leads to complete failure.

CRC 3-36 penetrates any scale formation and breaks the interfacial tension that binds corroded parts. It prevents fingerprint corrosion, aids cleaning and has a beneficial lubricating effect on moving parts.

CRC 3-36 will not trap moisture against the surface and its thin film will never become hard or brittle. It does not have to be removed before subsequent manufacturing operations.

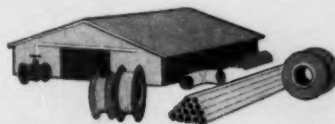
Whether your rust and corrosion control problem is related to storage of metal stocks, in-process material or equipment, packaging or shipping, CRC 3-36 does an effective job and will save its cost many times over by eliminating deterioration due to moisture.

Call your local industrial supply distributor for a trial order—today! Or, write for complete information to:

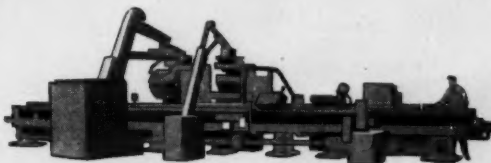
CORROSION REACTION CONSULTANTS,
a subsidiary of the Chas. J. Webb Sons Co., Inc.
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RUST AND CORROSION PREVENTION PROGRAMS

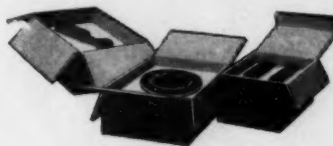
DURING STORAGE



DURING PRODUCTION



IN PACKAGING



OHIO WELDED TUBING

CORNERSTONE-LAYING WITH

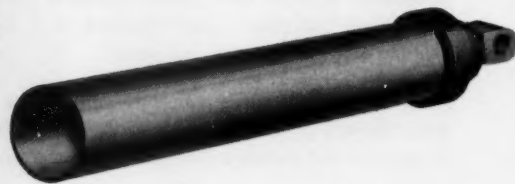
NO CEREMONY

In today's hustling, bustling construction business there's no time to stand on ceremony . . . no point in risking costly equipment failure.

To short-circuit mechanical downtime, leading construction equipment producers specify Ohio Tubing for power cylinders and fluid lines, mechanical and structural members. This gives equipment the heft and brawn to shrug off brutal, grinding punishment . . . gives equipment users a high degree of protection against disastrous delays.

You can strengthen your product — and its mechanical reputation — by specifying Ohio *Custom Made* Tubing. The name Ohio is the hallmark of the highest quality in tubing, both seamless and welded. And we're now able to deliver a broader range of welded tubing sizes, wall thicknesses and grades than ever before.

Let's not stand on ceremony. We want your tubing business — seamless to 7" OD, *welded up to 7½" OD*. For a fast start, contact your nearest Ohio representative, or send part drawings to the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry In America.*



Ohio Seamless offers the broadest parallel range of both welded and seamless quality steel tubing in the industry.

OHIO **OHIO SEAMLESS TUBE**
Division of Copperweld Steel Company • **SHELBY, OHIO**
Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Representatives in principal cities. Check leading directories: THOMAS', MacRAE'S, CONOVER-MAST, SWEET'S, FRASER'S.

Circle 415 on Page 19

A-3305A

Wood-Plastic "Alloy" Cracks Design Barrier

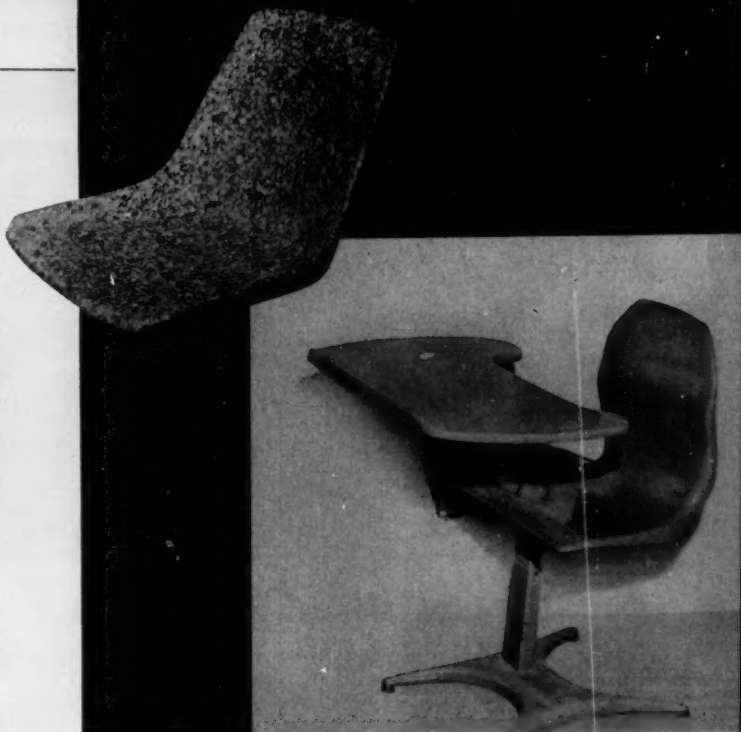
MADISON, Wis.—A careful blend of wood, chopped fiberglass, and polyester resin forms a new non-exotic material that has important design possibilities. Called Delwood, the "alloy" is especially effective in applications where wood would suffice, but where intricate curved or contoured surfaces have ruled it out. Delwood has proved extremely versatile, for example, as a reinforcing understructure for vacuum-formed vinyl shapes.

Molded in much the same manner as fiberglass or masonite, Delwood offers several unique advantages over ordinary wood:

- Receptacles or metal fasteners can be molded in.
- Parts are generally lighter in weight.
- Moisture resistance is superior.

The new material also excels in one other essential area: Cost. Either cast-iron dies or dies kellered from boiler plate are used in the molding process, which means that a bare minimum of machining is required. Quantity runs can thus be very low and still pay off.

Although most applications to date have involved products requiring a post-finishing operation, future uses of Delwood are expected to take advantage of a flake-surface process to achieve a fine finish. Responsible for Delwood is Gisholt Machine Co., Madison, Wis.



Designs in wood: Tractor seat and school desk are typical contoured products made of Delwood. Parts are molded at relatively low pressures—between 300 and 500 psi. Fracture strength of Delwood approaches that of hard maple; specific gravity is about 1.0. The material holds screws and nails better than wood, can be drilled and doweled in the same manner as wood.

From logs to Delwood: Chipper . . .



mixer . . .



molder



V-Belt Standard Ready for Approval

NEW YORK—Sponsor and ASA approval is all that is needed to put another important standard into effect. The proposed American Standard Specifications for Multiple V-Belt Drives has received the final touches from its sectional committee, which is jointly sponsored by the American Society of Mechanical Engineers and the National Machine Tool Builders' Association.

In the works since 1949, when ASA Sectional Committee B-55 took

over direction of the program, the new standard sets the dimensions and horsepower ratings of V-belts and sheaves in the A,B,C,D,E series, for industrial use. Automotive, agricultural, and appliance applications, covered by other specifications, are not included in this standard.

To be designated ASA B55.1-1961, the standard is based on *Engineering Standards, Multiple V-belt Drives* (1955 edition), published jointly by the Multiple V-Belt Drive

and Mechanical Power Transmission Association and the Rubber Manufacturers Association Inc.,

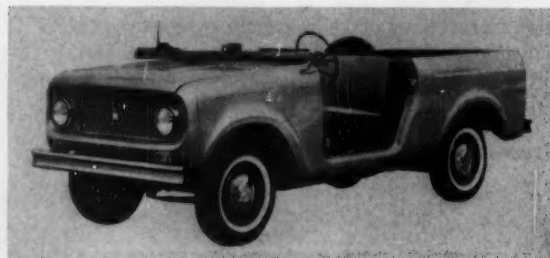
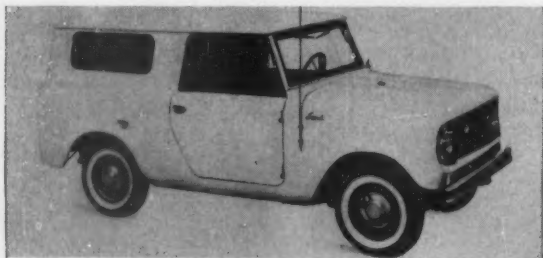
Two significant revisions, made during the past year, have simplified the standard: 1. The number of preferred belt lengths was reduced from 49 to 38; 2. Tabulation of horsepower ratings was reduced from two ("standard quality" and "premium quality") to one, which is the standard; ratings are equal to the former premium values.



Knock-Down Cab Aids Job-Hopping Truck

Exterior configuration is largely a matter of choice on International Harvester's new Scout utility vehicle. It converts from a conventional pick-up truck to an open runabout by means of removable steel top, removable doors and door glass, and a fold-down windshield. A full-length steel top that covers both the driver compartment and the 5-ft

pickup body is optional. Mounted on a 100-in. wheelbase, Scout is available as a 4 x 2 or 4 x 4. Both versions are powered by a four-cylinder valve-in-head engine which has a displacement of 152 cu in., develops about 90 hp at 4400 rpm. Suggested retail price of a 4 x 2 Scout: \$1598. Power takeoff, snowplow, and winch are optional.



Education: Engineers, Scientists Separate as Freshmen

CLEVELAND—What type of personality does the average engineering freshman have? And how does his personality affect his choice of career, his attitude toward education?

A recent survey of the freshman class at Case Institute of Technology, Cleveland, revealed, among other things, that the typical freshman fell into one of two categories—he was either 1. "A broad-gauged thinker, systematically organizing the facts of the world"; or 2. "A practical, hard-headed realist with a down-to-earth concern for the immediate present."

According to the survey, the practical man chose engineering as a major field, was more interested in managerial and administrative skills,

and hoped for family relationships as a main means of bringing satisfaction in life.

The theoretical man tended to choose science as a major field of study, relied on theoretical skills, and aimed for a scientific occupation. His concept of success was based jointly on family happiness and career satisfaction.

Requirements of the ideal job also varied between the two. The practical man thought it very important to earn a lot of money. The theoretical man thought it more essential to have an opportunity to use his special abilities and aptitudes, to be creative and original, and to be relatively free of supervision from others. The practical student felt it important to be liked by people—

to be able to convince and persuade them—and to have organizing and administrative ability. The theoretical man, on the other hand, considered a good grounding in basic theory to be more important.

In choosing curriculums, the practical men overwhelmingly chose engineering — metallurgical, civil, chemical, electrical and mechanical —while theoretical men, by a somewhat smaller majority, chose a curriculum in science.

Given a choice of three main goals in life—independence, success, or being well-liked—the most frequently expressed goal of the science student was to be independent. The next most frequent was to be successful. With engineering students, this order was reversed.

The new LICON[®] line . . . precision switches for every need

In the new, broadened Licon line you'll find every switch designed to meet modern high capacity, long life requirements. These are switches built to do today's tough jobs. Typical is the unique Type 16—heart of many Licon switch assemblies—tiny in size but rugged enough to handle big switch loads with unbelievable life. Check the unusual "specs" of the Type 16, and all Licon types, against your switch needs—see and compare Licon life against any switch—we're sure you'll specify Licon.

Send for catalog on new broad **Licon** line

—Gives handy dimensional data and engineering specifications you'll want to keep for ready reference.



Type 30 Enclosed Limit Switches—Interchangeable components form up to 16 switch types for quick replacement. High quality, compact, low-priced. 15A., 125V a-c for industrial applications.

H—Hermetically sealed Switches—Designed for dependability in extreme environments. Unique, true hermetic sealing against dust, moisture and other elements. Designed especially to your application.

Type 14 Heavy-duty Switch—Built for heavy industrial and machine tool service. Rugged snap-action has large contacts rated 30 amps at 250V a-c.

Type 10 Long-life Basic Switch—New Sero-tine action mechanism delivers 10 million operations without failure. Can be provided with movement differentials as low as .0005". Rated 15 amps.

Type 22 Double-pole, Double-throw Switches—Provide positive control of four independent circuits. Simplifies controls for multiple circuit applications—withstanding 25G at 2000 cps. Rated 15 amps., 115/250 V a-c, 50V d-c (res.).

P—Panel mounted Switches—Variety of types—to 8 or more poles—some solenoid reset or magnetically held—sealed and unsealed as required.

Type 11 Snap-action Switches—Resist 50G vibration to 2000 cps. Double break, snap-action design eliminates dead break, contact welding and provides greater capacity. Rated 10 amps., 115/250V a-c, 50V d-c.

Type 16 Subminiature Switches—Here's big-switch performance in a tiny unit. Only 1/8" thick, 28/32" long—yet rated 15 amps, 50V d-c ind. Greatest shock and vibration-resistance of any switch in its class on the market . . . even near trip point.



Licon

Circle 416 on Page 19

Available through your local Licon distributor.

DIVISION OF ILLINOIS TOOL WORKS
6806 W. Dakin Street, Chicago 34, Illinois

it
W

DEPENDABLE SWITCHING



of contact loads to 25 amps . . .

"Diamond H" Series W Relays—The simple, functional construction of this high-quality general-purpose relay assures long-time dependable switching. For a broad range of applications, specifying "Diamond H" Series W Relays makes good sense. Here are some reasons:

Reliable—Mechanical life in excess of 10,000,000 cycles.

Versatile—a-c or d-c units available with choice of eight different combinations.

Compact—Measures $1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{2}$ inches—weighs less than 10 oz.

High Contact Rating—Conservatively rated up to 25 amps, 240 v a-c or 28 v d-c.

Easy to mount—Plug-in design. Panel or side mounts also available.

Underwriters Laboratory Approval—U/L File 31481.

Cost-saving—Low in initial cost, the Series W is easy to install, saves space, and is easy to service.

Send for complete facts—in new 8-page Series W Relay Guide.


THE HART
MANUFACTURING COMPANY

118 Bartholomew Avenue, Hartford 1, Conn.
Phone JACKSON 5-3491

Circle 417 on Page 19

ENGINEERING NEWS

Meetings and Shows

Jan. 29-Feb. 3—

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 1-3—

Second Winter Military Electronics Convention to be held at the Biltmore Hotel, Los Angeles. Sponsors are the National Professional Group on Military Electronics and the Institute of Radio Engineers, Los Angeles section. Additional information is available from IRE, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Feb. 7-9—

Society of the Plastics Industry Inc. Sixteenth Reinforced Plastics Div. Conference to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 9-11—

National Society of Professional Engineers. Winter Meeting to be held at Hotel Fort Des Moines, Des Moines, Iowa. Further information can be obtained from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.

Feb. 13-16—

American Society of Heating, Refrigerating and Air-Conditioning Engineers. National Meeting and 15th International Heating & Air-Conditioning Exposition to be held at the International Amphitheatre, Chicago. Additional information can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Feb. 26-March 1—

First Pacific Electronic Trade Show to be held in the Great Western Exhibit Center, Los Angeles. Additional information can be obtained from PETS headquarters,

2216 South Hill St., Los Angeles 7, Calif.

March 5-9—

American Society of Mechanical Engineers. Gas Turbine Power Conference and Exhibit to be held at the Shoreham Hotel, Washington, D. C. Co-sponsor is the U. S. Dept. of Defense. Further information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 8-10—

Instrument Society of America. Annual Conference on Instrumentation for the Iron and Steel Industry to be held at the Roosevelt Hotel, Pittsburgh. Further information can be obtained from Richard R. Webster, Jones & Laughlin Steel Corp., Research Laboratory, 900 Agnew Ave., Pittsburgh 30, Pa.

March 11-14—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 12-16—

American Society of Mechanical Engineers. Aviation Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 13-15—

American Rocket Society. Flight Testing Conference to be held in



"Now if you can design a rocket shaped like a slice of bread . . ."

MACHINE DES:GN



Dow Corning

SILICONE NEWS

for design and development engineers • No. 79

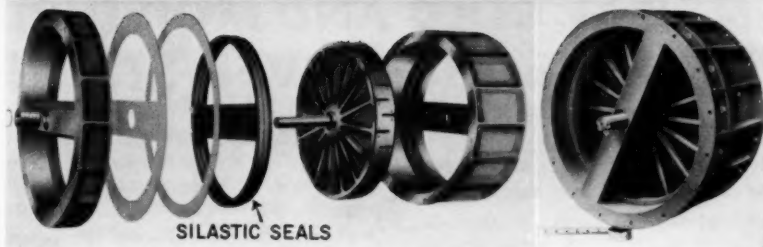
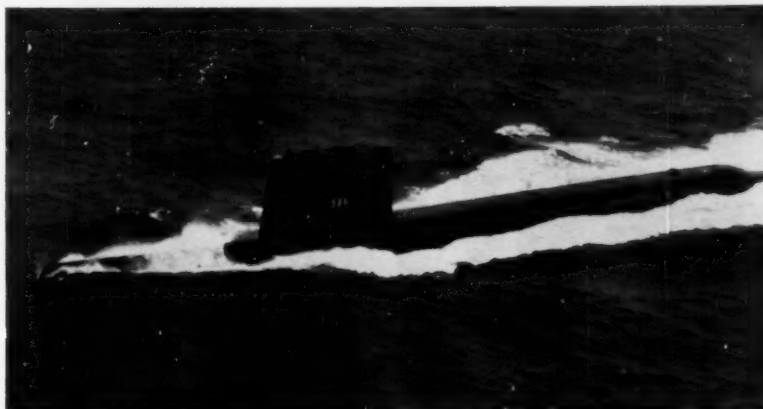
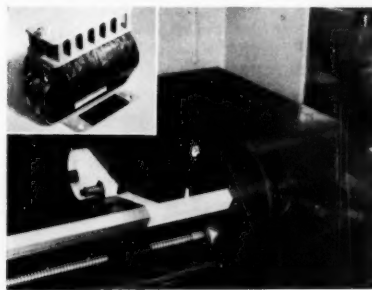
SILICONE RESIN HELPS MEET TOUGH SPECS

Solventless silicone resin helps meet stringent reliability requirements. Example: transformer start tubes manufactured by Osborne Electronic Corporation, Portland, Oregon.

Osborne manufactures specialized high-performance transformers that are virtually standard equipment on major jets, such as the B-52, KC-135 and 707. To produce top quality start tubes of special sizes and shapes, Osborne engineers wrap glass tape on a mandrel, saturate it with Dow Corning solventless silicone resin, and then cure the tube form by heating.

These silicone-glass tubes meet all of Osborne's construction, performance and reliability requirements:

a. Retain mechanical and dielectric strength from -65 to 200°C . . . resist intermittent exposure to 250°C . (Cont. Pg. 2)



DESIGN "THROUGH" SEALING PROBLEM

Silicone engineering materials often enable you to design "through" rather than "around" a problem. A heat exchanger manufactured by the Air Preheater Corporation, Wellsville, N.Y., provides a fine example.

Air Preheater makes rotary regenerative heat exchangers for atomic submarine air purification systems. When these extremely compact units are in operation, heat of the purified air pre-warms the stale air before it goes to the catalyst bed. Thus, the air entering the system is raised from room temperature to 575°F , and the purified air is cooled from 650°F to 175°F . This procedure, designed to aid efficiency, saves a combined heating and cooling load of about 70 kw.

Heart of the heat exchanger is the rotor . . . and sealing the rotor seemed like a major design problem . . . until Air Preheater engineers designed through the problem with Silastic®, the Dow Corning silicone rubber.

The Silastic foam cushion seal remains resilient in high temperature service; withstands compression loading created by rotor expansion; and has good resistance to friction and tearing action of the rotor. According to the designers, much of the success of the preheater can be attributed to the method of sealing.

No. 241

New Insulating Effectiveness

A new, more durable, kind of wire and cable insulation that performs reliably under adverse operating conditions . . . is described in this special bulletin for electrical and electronic designers.

The insulation is Silastic®, the Dow Corning silicone rubber. A flexible material that's really tough, it opens new design concepts for wire and cable . . . provides low cost insurance against failure.

This new fact-filled, six-page bulletin cites typical applications in aircraft, appliances, commercial and industrial building, shipboard, and electrical and electronic equipment . . . points up how engineers are utilizing the properties of Silastic insulated wire and cable to best advantage.

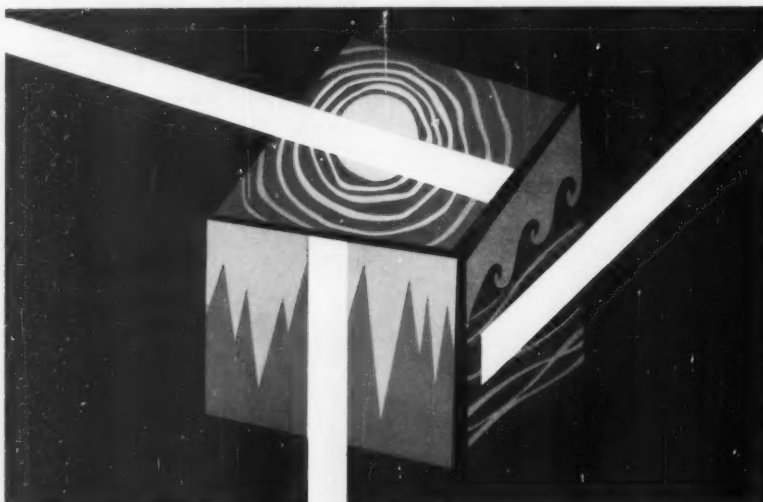
Longer service life of Silastic is attributable to its excellent heat stability, resistance to ozone, corona and oxidation, flexibility at low temperatures, good weathering and storage stability.

To obtain a copy of this engineers' reference — to learn how Silastic wire and cable insulation can help you design equipment that will perform longer and more reliably despite heat, cold, moisture, weathering, corrosive vapors, ozone and corona, circle . . . No. 242



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MORE



new literature and technical data on silicones

We've recently published a series of new booklets, each describing the silicone products of interest to a specific industry. These references cite how different forms of silicones can help you design products that perform more reliably and meet requirements encountered in diverse applications. Send for your reference copy.

Silicones for the Automotive Industry is the subject of an 8-page brochure that cites illustrations and descriptions of the many research, engineering, and automotive production applications wherein silicones make possible superior performance. Some of the applications include power plants, braking systems, power transmissions, electrical components, surface protection, lubrication, and many more applications of interest to every design engineer. **No. 245**

Electronics Engineer's Guide describes all the silicone products that contribute to reliability, miniaturization and environmental protection of electronic components. From satellites to seismographic instruments, this 16-page electronics engineer's guide describes the various forms of silicones that help improve design. **No. 246**

Silicones in Appliances can give that extra edge for extra sales. This colorful booklet tells where and how silicones are being designed into appliances to give more efficient and reliable performance. Illustrations show how planning around silicones can make good products better. **No. 247**

Space Age Silicones are described in thirty typical application stories. Utilization of silicone compounds, fluids, lubricants, protective coatings, rubbers, resins, potting materials and sealants are illustrated for your consideration. This valuable brochure offers solutions to many problems encountered in designing space age aircraft and ground support equipment. **No. 248**

Now available: How Silicones Work for the CPI. Chemical process engineers will find this the most comprehensive description of how and where silicones can be utilized to expand capacity, cut costs, increase reliability, and improve ambient conditions for their industries. **No. 249**

IN HEAT, COLD AND MOISTURE SILICONE ADHESIVES STICK!

The exceptional durability of pressure-sensitive silicone adhesives makes them dependable for tapes, sealants, spray-on coatings, bonding materials and splicing agents.

• **They stick anywhere!** At temperatures from -80 to 500 F, pressure-sensitive silicone adhesives stay stuck and don't deteriorate. They withstand the effects of moisture, oxidation, corrosive chemicals, weathering, arcing, corona and fungus. For electrical applications, silicone adhesives provide excellent dielectric strength.

• **On tapes.** Dow Corning silicone adhesives are used with most backing materials.

Now readily available from several manufacturers are tapes with backings of glass cloth, Teflon, Mylar, aluminum foil, silicone rubber and combinations of these materials. Typical applications include: high temperature electrical insulation; bonding, splicing, and sealing; masking in chemical milling, and release surfacing.

• **Or alone.** For positive, dependable fastening in rugged service, some designers use silicone adhesives to seal heat elements in appliances, bond mica and asbestos panelboard, and bond silicone rubber to the coils of electrical equipment.

Dow Corning Silicones may well be your adhesive of the future. **No. 243**

SILICONE RESIN (Cont.)

b. Cure bubble-free without voids or pin holes. Easily applied by brushing, the solventless silicone resin penetrates completely and uniformly.

c. Readily withstand wire winding pressure without distorting.

d. Are easily fabricated in short runs, in great variety, with simple tools. Require only a heat cure, no pressure. Cured forms

are easily cut, notched and machined.

The reliability of the silicone-glass start tubes and Osborne transformers has been proved repeatedly by the thousands of transformers now in service. Comments Osborne's chief engineer: "In destruction tests in which the transformer coil is deliberately burned out by overloading, the silicone-glass start tube is blackened but retains most of its electrical and mechanical strength." **No. 244**

Dow Corning Corporation, Dept. 4913, Midland, Michigan

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246 247 248 249

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Los Angeles. Further information is available from ARS headquarters, 500 Fifth Ave., New York 36, N. Y.

March 13-17—

National Association of Corrosion Engineers. Annual Conference to be held at the Statler Hotel, Buffalo. Additional information can be obtained from NACE headquarters, 1016 M & M Bldg., Houston 2, Tex.

March 13-17—

Society of Automotive Engineers Inc. National Automobile and Production Meetings to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 16-17—

American Society of Mechanical Engineers. Textile Engineering Conference to be held at Clemson College, Clemson, S. C. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 20-23—

Institute of Radio Engineers. International Convention to be held at the Coliseum and the Waldorf-Astoria Hotel, New York. Additional information is available from IRE, 1 E. 79th St., New York 21, N. Y.

March 20-24—

American Society for Metals. Thirteenth Western Metal Exposition & Congress to be held at the Pan Pacific Auditorium, Los Angeles. Additional information can be obtained from ASM, Metals Park, Novely, Ohio.

March 21-23—

American Power Conference to be held at the Sherman Hotel, Chicago. Sponsors are nine engineering societies, including American Society of Mechanical Engineers, National Association of Power Engineers, American Institute of Electrical Engineers, American Society of Civil Engineers, and American Society of Heating, Refrigeration, and Air Conditioning Engineers; Illinois Institute of Technology and 13 other universities. Additional information can be obtained

ENGINEERING NEWS

from R. A. Budenholzer, Illinois Institute of Technology, 35 W. 33rd St., Chicago 16, Ill.

April 4-6—

National Microfilm Association. Tenth Annual Meeting and Convention to be held at the Sherman Hotel, Chicago. Additional information can be obtained from the association's executive secretary, Vernon D. Tate, P. O. Box 386, Annapolis, Md.

April 4-7—

Society of Automotive Engineers Inc. National Aeronautic Meeting, including production forum and display, to be held at the Hotel Commodore, New York. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

April 6-7—

American Society of Mechanical Engineers-Society for the Advancement of Management. Management Engineering Conference to be held at the Statler Hilton Hotel, New York. Further information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Short Courses and Symposia

Feb. 3-4—

Industrial Engineering Institute to be held at the University of California, Los Angeles. Discussion topics will include factors in both human and machine production and future development of operations research. Additional information is available from Dept. K, University of California Extension, Los Angeles 24, Calif.

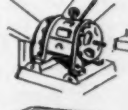
Feb. 14-16—

Second Annual Symposium on Nondestructive Testing of Aircraft and Missile Components (unclassified) to be held at the Gunter Hotel, San Antonio, Texas. Sponsors are the South Texas Section of the Society for Nondestructive Testing Inc. and Southwest Research Insti-

TORQ SPEED DETECTION CONTROL

...may solve
YOUR problem

✓SIMPLY
✓POSITIVELY
✓ECONOMICALLY



Patents & Patents Pending

TORQ ENGINEERED PRODUCTS, INC.
26 West Monroe Street Bedford, Ohio
Phone: Bedford 2-4100

• A single TORQ SYNPRO-TEX governor cycles an automatic washer during spin-dry to less than 1G to more than 1G to balance the load, get clothes drier and make the wash "fluffy".

• A TORQ MULTICTOR practically runs a diesel engine. It cuts out cranking motors, engages and disengages cooling circuit, provides fuel requirements at different speeds, then signals full speed.

• TORQ governors relate fuel supply to air supply in power gas burners. A single governor will purge the combustion chamber, then turn on the gas, and during operation if blower falls below required speed for any reason, the governor shuts off the gas.

• In event of overload on a saw mill, due to dull blades, a TORQ governor causes the cutting blade to be withdrawn before damage can occur.

• On electronic equipment blowers, a TORQ governor will cut the equipment out of the circuit in event of blower failure, to protect expensive electronic components against overheating.

• Conveyors are automatically shut off if they fall below predetermined safe speed.

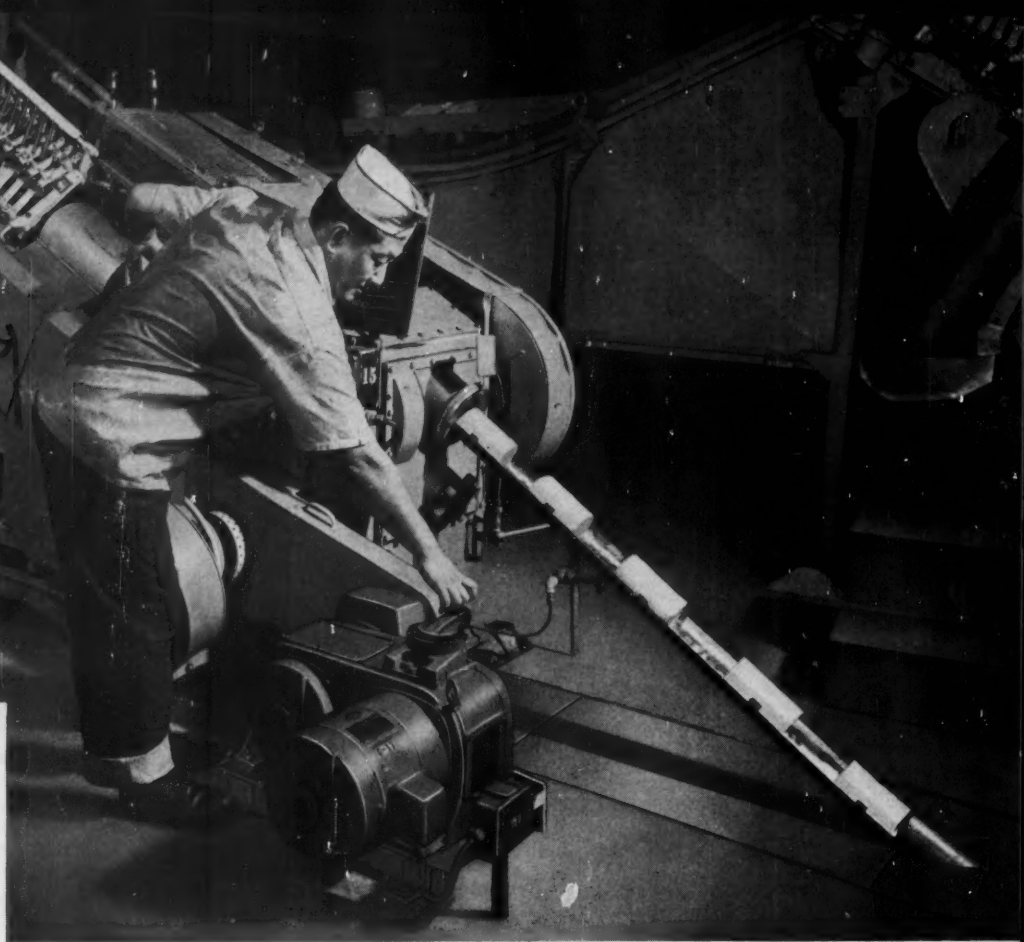
• TORQ governors make an ideal plugging switch to cut out the motor at low speeds close to zero before motor reverses.

• On truck refrigerators, TORQ governors maintain proper voltage and frequency output from the alternator by shifting it through a solenoid actuated transmission at pre-calculated truck engine speeds.

If your device employs a rotating shaft, a TORQ governor can sequence it, control it, provide signals, or monitor it for safety at one or many speeds from zero to more than 15,000 rpm.

Write today for Bulletin No. 250.

Circle 418 on Page 19



Mr. R. A. Weaver, Electrical Superintendent,

Dole Hawaiian Pineapple Company states: "On the

basis of evaluation and comparison with other drives...

**We found General Electric Polydyne® Drives
best meet our adjustable-speed requirements."**

At Dole Hawaiian Pineapple Company's Honolulu Cannery, "Ginaca" processing machines can automatically reduce whole pineapples into separate "components" of core, rind, pulp and a cylinder ready for final processing at a rate of up to 6000 per hour. With a constant-speed motor drive it is necessary to stop and start a Ginaca to control output. However, the Polydyne Drive can match the varying conditions at each stage of the processing system. The adaptability of Polydyne Drives reduces the need for supervisory attention and permits maximum processing efficiency.

Dole Company personnel selected General Electric's Polydyne Drives for the quick and smooth response to speed adjustments demanded by their continuous processing system. As Mr. Weaver also commented,

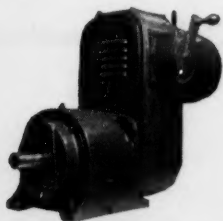
"In our evaluations and comparisons with other drives we gave particular attention to ease of belt replacement because this makes maintenance simple and reduces downtime. We found Polydyne Drives far superior to other drives for making belt changes quickly."

When your application requires low-cost adjustable speed combined with reliability and ease of maintenance, investigate G-E Polydyne Drives. Your General Electric Sales Engineer has full details. Or, write for bulletin GEA-6806, Section 854-05, General Electric Company, Schenectady 5, N. Y.

GENERAL  ELECTRIC

**GENERAL ELECTRIC
OFFERS A COMPLETE LINE
OF LOW-SPEED DRIVES
1/8 TO 200 HP**

Select from G.E.'s PLUS LINE of compact mechanical power transmission equipment! A full range of ratings is available—many directly from stock.



General Electric Polydyne Drive



Integral-type Gear Motor



Right-angle Shaft Gear Motor



All-motor Gear Motor



Footed Speed Reducer



Shaft-mounted Speed Reducer

Member of
American Gear Manufacturers' Association

GENERAL ELECTRIC

ENGINEERING NEWS

tute; further information is available from R. B. Wangler, Southwest Research Institute, P. O. Box 2296, San Antonio, Texas.

Feb. 22-23—

Seminar on Automation and Numerical Control, sponsored by the American Society of Tool and Manufacturing Engineers, to be held at the Bond Hotel, Hartford, Conn. Additional information is available from ASTME, 10700 Puritan Ave., Detroit 38, Mich.

March 20-31—

Industrial Packaging Short Course to be held at Purdue University. Additional information is available from Mark E. Ocker, Conference Co-ordinator, Div. of Adult Education, Memorial Center, Purdue University, Lafayette, Ind.

March 27-31—

Third Symposium on Temperature—Its Measurement and Control in Science and Industry to be held at Veterans Memorial Auditorium, Columbus, Ohio. Sponsors are Instrument Society of America, American Institute of Physics, and National Bureau of Standards. Further information is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

March 28—

17th Annual Quality Control Clinic to be held at the University of Rochester, Rochester, N. Y. Sponsor is the Rochester Society for Quality Control. Further information can be obtained from Albert D. Rickmers, Associate Professor, College of Graphic Arts and Photography, School of Photography, Rochester Institute of Technology, 65 Plymouth Ave. South, Rochester 8, N. Y.

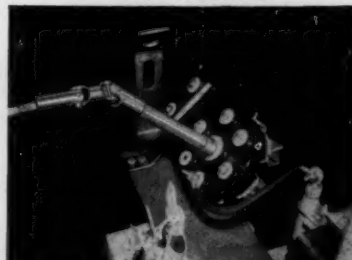
March 28-29—

Symposium on Nucleonics in Flight to be held at the Statler-Hilton Hotel, Dallas, Texas. Symposium will consider nuclear aspects of atmospheric and space systems for manned and/or unmanned space travel. Further information is available from Eldred L. Burkhard, Chairman, North Texas Section, American Nuclear Society, Convair Div., Fort Worth, Texas.

January 19, 1961



**CURTIS HELPS
THIS SWITCH LIVE TO
A RIPE OLD AGE**



Pad-mounted transformers for underground power distribution systems are built to last a lifetime. They require a minimum of maintenance. Settings are changed infrequently. But when a change is required, this switch must operate smoothly and surely. To insure a long, dependable life, without freeze-ups or rust-outs, the manufacturer equipped it with a Curtis C-646 1" O.D. Stainless Steel double universal joint.

This kind of dependability is the stock-in-trade of Curtis joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, continuous testing, inspection and quality control at every stage of manufacture — these are some of the things that make Curtis joints your most dependable buy.

**14 SIZES ALWAYS IN STOCK
3/8" to 4"**

Not sold through distributors. Write or phone Republic 7-0281 for latest catalog, free engineering data and price list.

CURTIS
UNIVERSAL JOINT CO., INC.

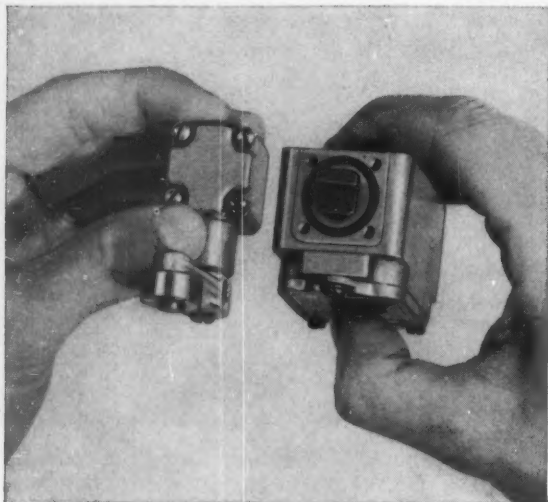
51 Birnie Ave., Springfield 7, Mass.

As near to you as your telephone. Exclusively a manufacturer of universal joints since 1919

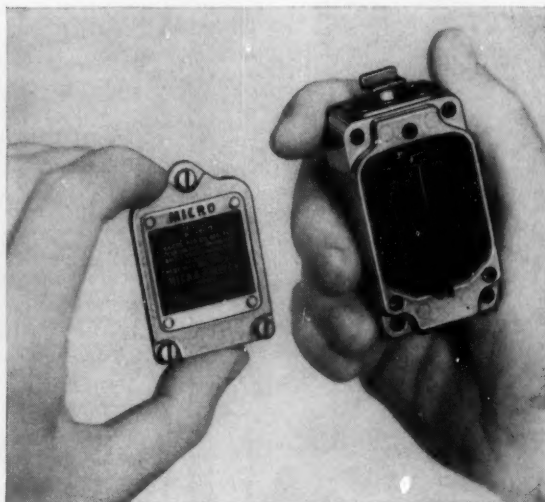
Circle 420 on Page 19

Check MICRO's big advantage

See just how readily adjustable—and durable
by making MICRO SWITCH's convincing



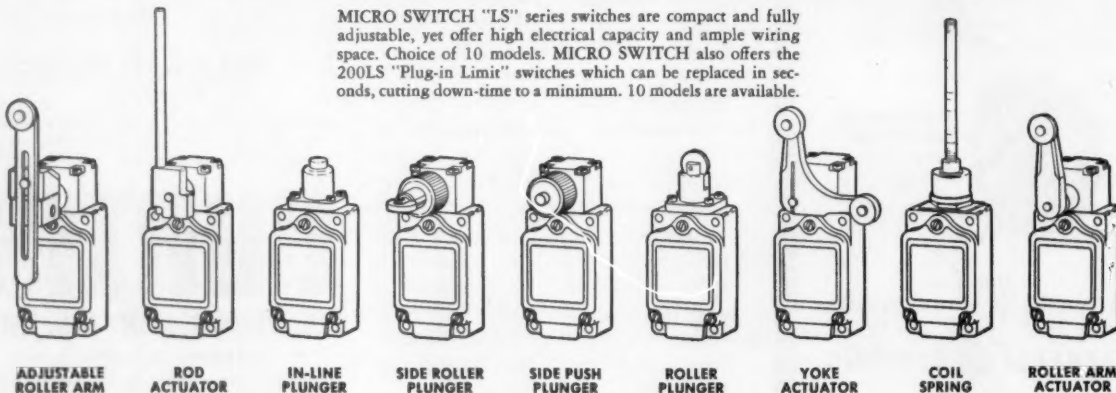
In just twenty seconds check the easy adjustability. Remove just four screws, lift actuator head, turn the plunger shown inside the embedded "O" ring seal. Replace actuator head facing in direction desired—front, back, left or right. Roller arm also has 360-degree adjustability.



It's easy to remove the faceplate for terminal connections in 20 seconds! Captive screws make it quick and easy to remove and replace the faceplate whenever wiring changes are necessary. Oiltight and dust-proof seals on the faceplate, beneath the actuator head and on the roller arm shaft, guard against fouling.

9 Different Actuators for Cost-Cutting Versatility

MICRO SWITCH "LS" series switches are compact and fully adjustable, yet offer high electrical capacity and ample wiring space. Choice of 10 models. MICRO SWITCH also offers the 200LS "Plug-in Limit" switches which can be replaced in seconds, cutting down-time to a minimum. 10 models are available.



ADJUSTABLE
ROLLER ARM

ROD
ACTUATOR

IN-LINE
PLUNGER

SIDE ROLLER
PLUNGER

SIDE PUSH
PLUNGER

ROLLER
PLUNGER

YOKE
ACTUATOR

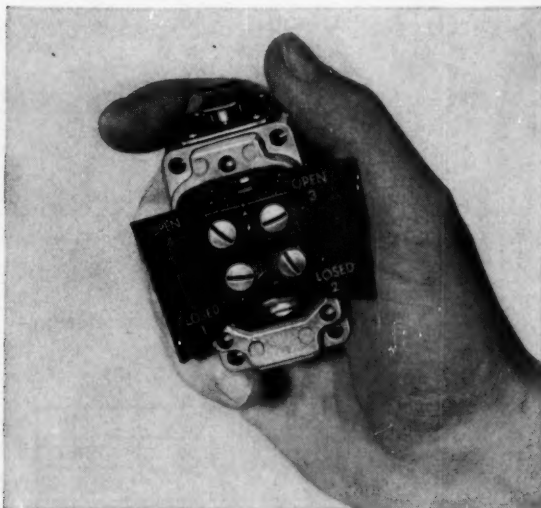
COIL
SPRING

ROLLER ARM
ACTUATOR



-rugged simplicity!

a limit switch can be,
45-second screwdriver test



Check the advantages of MICRO's basic switching unit in just 5 seconds! Stepped design allows extra space for easy wiring. Precision switching unit is self-contained, factory adjusted and replaceable. Heavy-duty #8 screw-type terminals.

The rugged simplicity of the MICRO SWITCH "LS" series offers many advantages where high adjustability, compactness and heavy-duty electrical capacity are needed. As you've just proven yourself, these switches can be fully adjusted in a matter of seconds, making change-overs much simpler and far less costly. Compact in size, they fit in many places too small for any other fully adjustable limit switch. Yet they are big in electrical capacity . . . made to handle the same electrical loads as much larger switches. The rugged aluminum-alloy housing protects the precision switching unit from physical damage, and the entire unit is completely



ACTUAL SIZE

sealed, oiltight and dust-proof to prevent fouling.

The many time and money-saving features of this switch are true of the entire family of MICRO SWITCH limit switches. Rotary-actuator heads may be mounted in any of four positions. All models of rotary-actuator switches can be set to be operated electrically in both directions; or only to the left or right. Lever arms adjust through 360 degrees. Roller levers may be faced in either direction. And roller plungers can be faced at 90° increments.

See the Yellow Pages for the name of the nearby MICRO SWITCH branch office, or write for Catalog 84.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell

In Canada: Honeywell Controls Limited, Toronto 17, Ontario



Honeywell
MICRO SWITCH Precision Switches

"Featherweight" BEARINGS ... by MESSINGER



The Answer
to High Load-Carrying Capacity
With Substantial Reduction in
Over-all Weight of Product.

Two Hundred Forty Standard Sizes...
Offering Widest Latitude in Design
Applications...

From

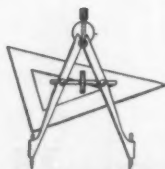
I.D.	O.D.	WIDTH
2.00"	2.50"	.250"

To...

I.D.	O.D.	WIDTH
60.00"	62.00"	1.00"

Minimum and maximum cross-sections for
range of standard sizes are shown in actual
size, at left.

In contrast with their extremely light weight and slender section, these "FEATHERWEIGHTS", like all other Messinger Bearings, are made to give years of precision performance under surprisingly heavy loads. They lend themselves to an exceptionally broad range of applications in the design of appliances, instruments, machinery and equipment of many types. Write for Catalog No. 59.



You can "work wonders" with product design when you consider "Featherweight" Bearings by Messinger. Consultation invited, without obligation.

MESSINGER  **BEARINGS, Inc.**
ROLLER AND BALL BEARINGS FEATHERWEIGHT TO HEAVYWEIGHT
D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.
"Smoothing Industry's Pathway for Nearly Half a Century"

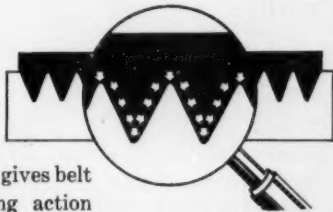
DAYTON POLY-V® Drives pack more power in smaller spaces

*Offer engineers greater
versatility in drive design*

Dayton Poly-V Drives are *single* units. They run in sheaves designed to mate perfectly with belt ribs. This provides twice the tractive surface per inch of sheave width . . . up to 50% more power in $\frac{3}{4}$ the space. Result—a more compact, lighter drive . . . less shaft overhang.

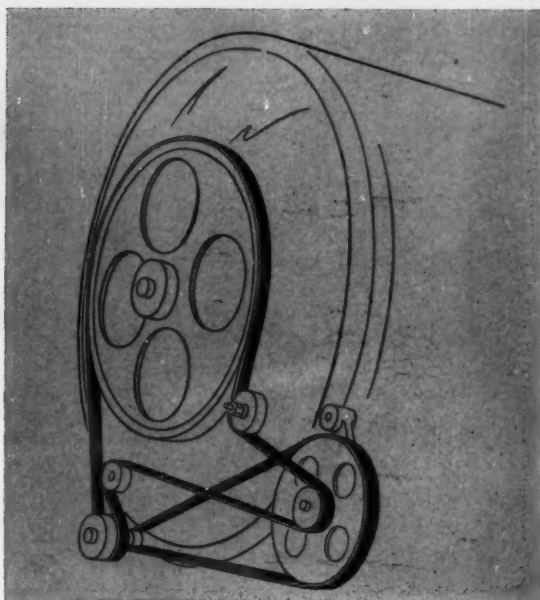
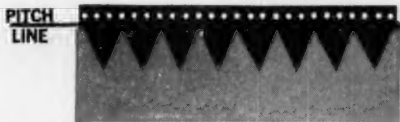
Greater horsepower capacity

Full contact design gives belt ribs greater gripping action in sheave grooves. Belt tension is transferred equally and in all directions through the belt ribs to the sheave groove walls (hydrostatic principle).



Uniform speed ratios

Full contact design distributes the load equally over the entire contour of the V-ribs. Peak loads cannot cause the Poly-V belt to ride lower in the sheave grooves. Pitch diameters and speed ratios remain constant from no load to full load condition.

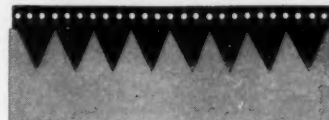


Vibration free



Full contact design guarantees smooth, vibration-free operation. Full molded surface has complete contact with the sheaves. Poly-V belts have uniform belt thickness—no slipping . . . no creeping.

Greater flexibility



Reduced belt thickness means smaller sheave diameters (as small as $\frac{3}{4}$ " with "J" belts)—less centrifugal force. This permits operations at higher belt speeds (up to 10,000 FPM for Poly-V "J")—ideal for high speed motors.

Simplified drive design

Only 3 Poly-V cross sections are required:

- "J"—from fractional to 10 HP
- "L"—for intermediate drives (5 to 50 HP)
- "M"—for high HP drives (25 HP and up)

See your Dayton engineer

Let Dayton's Engineering Service help you with your drive design. Call or write:

®Registered trademark of R/M Inc. Manufactured by Dayton Corp. under exclusive license of Raybestos-Manhattan, Inc.

©D.C. 1961.

INDUSTRIAL DEPARTMENT

Dayton Industrial Products Co.

2001 Janice Ave., Melrose Park, Ill.

Division of Dayton Corporation

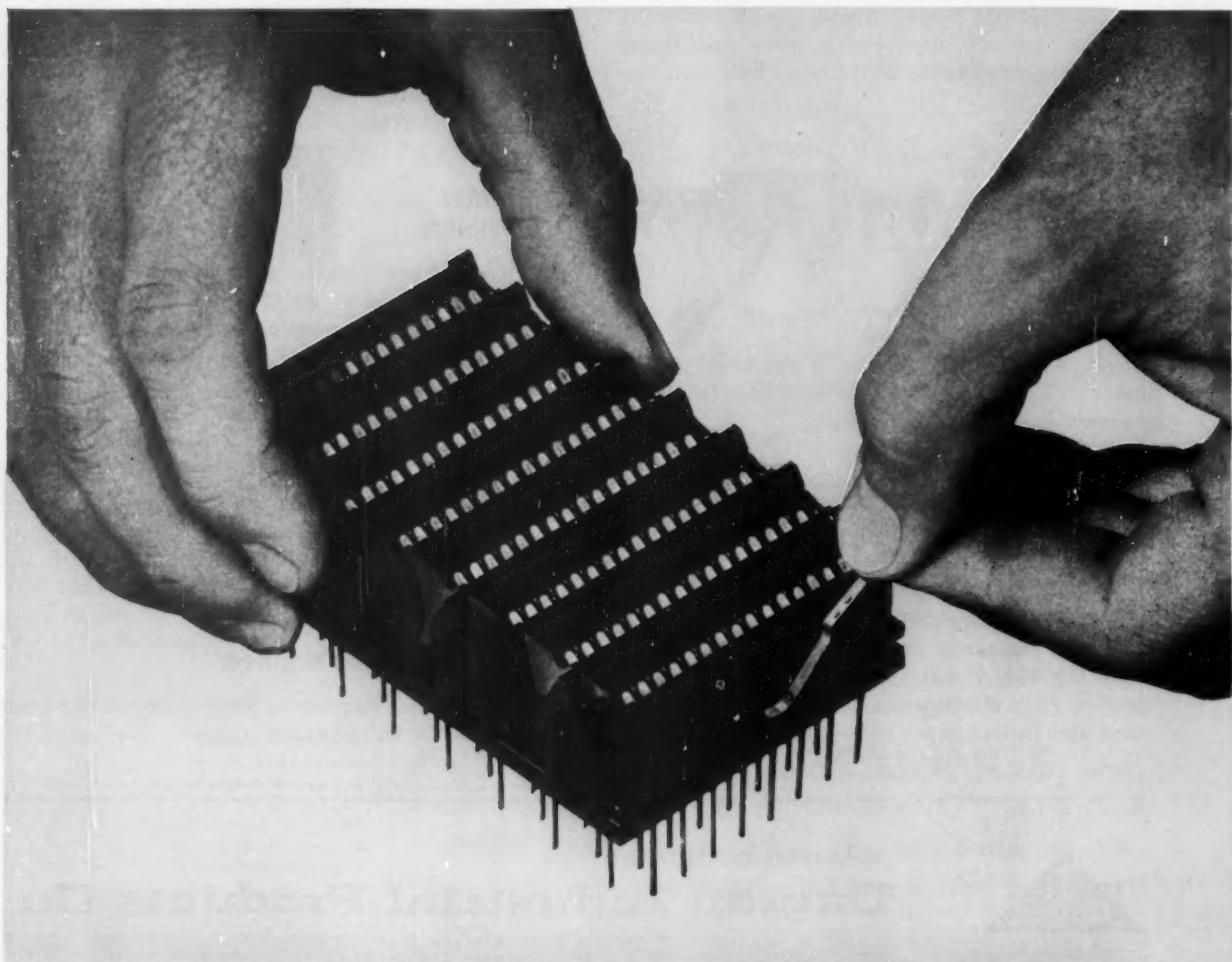
SYLVANIA PRODUCES & DELIVERS THE COMPLETED ASSEMBLY

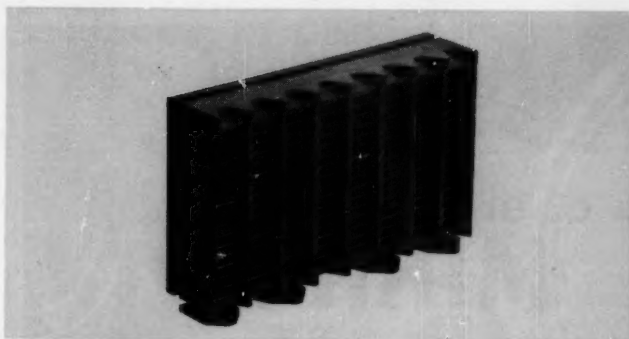
—at substantial savings to IBM

This electrical connector block is a vital link in the electrical system of an IBM computer. Unless it is built to exact tolerances, the computer can malfunction.

To make this critical part, IBM chose Sylvania because we could perform the entire production sequence—from raw materials to completed assemblies built to tolerances in terms of thousandths of an inch. It soon proved the

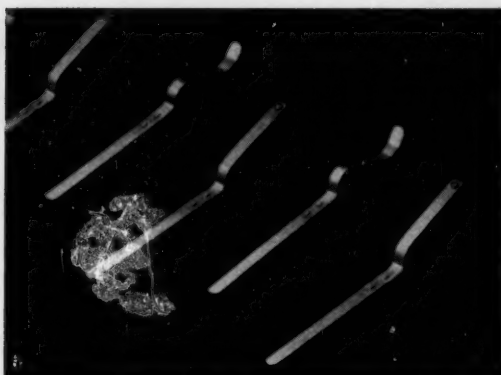
Sylvania experience paid off in two ways: in production economies and in fast delivery too. Total result: a better connector block—at lower cost. (For details see captions to pictures on these pages.) For full information on how Sylvania custom facilities can benefit *you*, or for a quote on a specific project, write Sylvania Electric Products Inc., Parts Division, Warren, Penn.





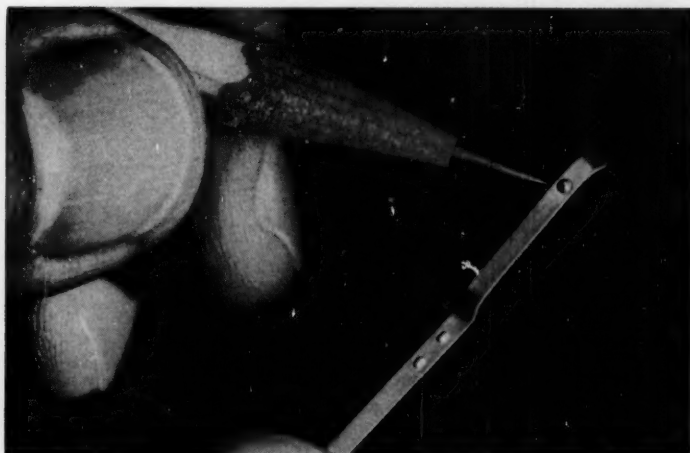
MOLDED FROM PLASTIC by Sylvania, the IBM connector block meets tightest specifications. This is possible because Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment. This equipment permits Sylvania to handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to IBM? Precisely formed parts to fill high-volume requirements.

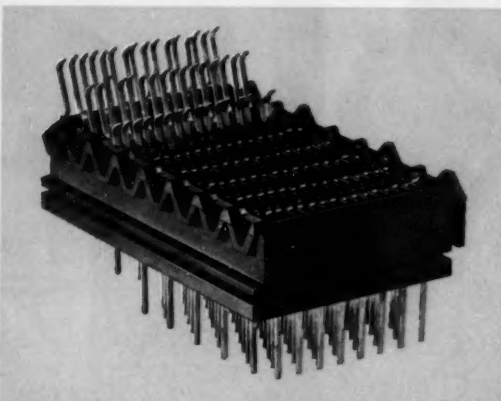


MADE FROM SYLVANIA WIRE, precision-rolled ribbon connectors offer high reliability when the circuitry is completed using wire wrap contact methods. The cross section of the ribbon—.023" x .062"—and the corner radius of .003" were accomplished on a special three-head tandem rolling mill and special forming equipment.

Result of this flexibility to IBM? Top reliability at close tolerances.



CUSTOM METAL STAMPING AND DOT WELDING, in one operation, also paid big dividends to IBM. The original plans called for forming parts and then gold-plating the entire contact. Following a request by IBM to extend contact life and reduce costs, Sylvania experience paid off. Sylvania Engineers demonstrated they could weld a tiny gold dot at the contact point economically while maintaining close tolerance on the critical dimensions of the formed contact. High-speed, high-volume techniques enable Sylvania to meet critical deflection and shear tests. Sylvania maintains a metal stamping facility which includes multi-slide machines, vertical presses, and specially developed machines to help solve your special problems.



CUSTOM ASSEMBLY by Sylvania of the block and the parade of contacts is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or all customer components, or both—at lower cost than is possible in the customer's own facilities.

Result to IBM? Many, many thousands of completed top-quality assemblies per month, and to tolerances specified for automatic wire wrap.

QC SERVICE MEANS QUALITY CONTROL!

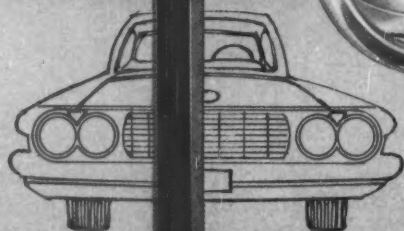
At Sylvania, a tough-minded, hard-to-please quality control department has full authority for assuring the parts Sylvania produces meet your most stringent specifications. Example of this thoroughness: for the IBM connector block, Sylvania used 100% inspection!

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**



when you count on
MIRRO
 you can count on
DEPENDABILITY



THE
 METAL MEN
 OF
 MANITOWOC



COUNT ON 'MIRRO for any production line requiring aluminum components...appliances, housewares, automotive, or Government contracts.



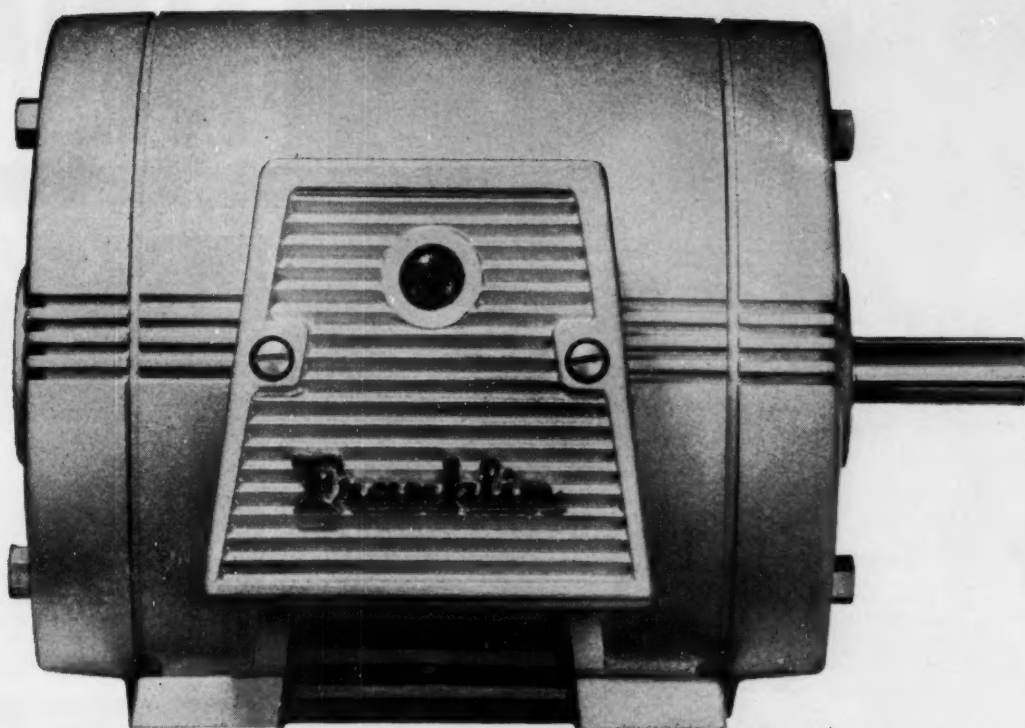
The unit above offers current proof. It is one of two headlamp assemblies—left and right—that MIRRO is making for three fast-selling 1961 series of a major automobile manufacturer.

When an automotive production line is scheduled to roll on a new model-year, components must be on hand, must fit, must meet a rigid Accepted Quality Level—and must, of course, come in at a carefully estimated cost. Failure in any of the first three of these requirements would stop the assembly line cold and cause countless cost and production problems. Failure to meet the estimate would be equally upsetting to the established price structure.

This manufacturer's new-model lines started and, for the first few weeks, *depended wholly* upon MIRRO-made headlamp assemblies. Later, when sales demanded faster production than originally expected, MIRRO was again depended upon for a stepped-up delivery schedule.

Count on MIRRO and you can count on that kind of quality-conscious, cost-conscious, calendar-conscious dependability, backing any contract job you place with us. We'd welcome a chance to estimate or advise.

MIRRO ALUMINUM COMPANY, MANITOWOC, WISCONSIN
 Fifth Avenue Bldg., New York 10
 Merchandise Mart, Chicago 54

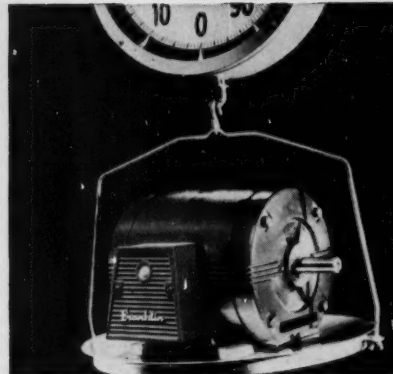


**ALL NEW
FRANKLIN
STANDARD
MOTORS
WEIGH
UP TO 30%
LESS THAN
ORDINARY
INTEGRAL
MOTORS**

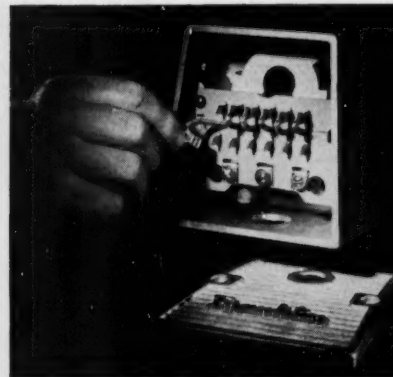


Read about this engineering accomplishment on the next two pages ... Also on the next page—news of a contest for design engineers only!!

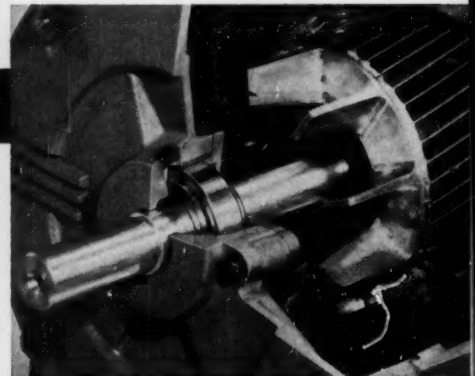
NEW!



ALUMINUM CONSTRUCTION of the new Franklin motor gives the designer terrific weight advantages, plus faster heat dispersion and freedom from rust and corrosion. Strong, too.



QUICK-CONNECT TERMINAL BOARD comes pre-connected to your specified voltage. Eliminates time-consuming taping and wiring. And your customers can change the voltage in 1 minute flat!



PRELUBRICATED AND DOUBLE SHIELDED BEARINGS absolutely exclude all contaminants, eliminate the chief cause of motor bearing failure. Internal labyrinth seal keeps the grease in the bearings, out of the windings.

→ Franklin Integral Motors are made of Aluminum...

YET THEY'RE STRUCTURALLY STRONGER THAN COMPARABLE CAST-IRON MOTORS!

Here's news of a new, feather-weight motor you can apply *now* to your product.

Franklin Electric has designed an integral HP motor that gives you the light weight of aluminum ... with a shock resistance greater than cast iron!

Aluminum frame, end-bells, rotor, and conduit box are combined to give you an average of 30% *less weight* per motor rating.

You actually design weight *out* of your product by using this new, lighter motor. You'll need less bracing and support. And the Franklin lightweight is far easier to handle on your assembly lines. Less worker fatigue, faster assemblies. What's more, your shipping costs go down automatically with the over-all weight reduction!

Aluminum has other advantages for you, too: greater thermal conductivity for cooler running, and a high resistance to rust and corrosion.

How many times could you have used these other Franklin features:

1. Pre-packed, double shielded bearings that absolutely exclude contaminants (chief cause of bearing failures in ordinary motors). There's an unusual labyrinth seal on the shaft that keeps grease in the bearings, not on the shaft. And a grease reservoir that practically eliminates the need for regreasing.
2. Quick-connect terminal board that arrives pre-connected to your specified voltage. No more taping and wiring. Terminal connectors make line connections in a matter of seconds.
3. Two-year guarantee from date of manufacture.

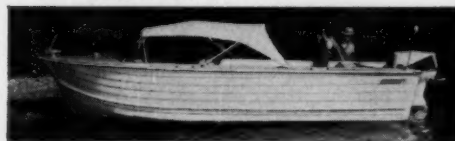
4. Inherent protector space *built-in* to the conduit box. The clean lines of this motor will stay clean. No add-ons.
5. Identical NEMA single and polyphase motor frame sizes. They're completely interchangeable, so you need carry no extra bases in stock.

And plenty more designer-requested features that can help you cut costs and increase the efficiency of your motor-driven product. For the complete story, just send in coupon below for a free, full-color brochure which explains this new motor line in detail. And while you're at it, enter the Franklin "Name the Aluminum Motor" contest explained below. Send in the coupon today.



Franklin® Electric Co., Inc.

BLUFFTON, INDIANA



Name the Aluminum Motor Contest... for Design Engineers only!

WIN A FULLY EQUIPPED STARCRAFT ALUMINUM BOAT AND EVINRUDE MOTOR!

Send your suggestion for a name for the all-new Franklin aluminum motor on the coupon at right. First prize—a 16 ft. Starcraft aluminum "Jupiter" runabout and a 40 h.p. Evinrude outboard motor. Twenty additional runner-up prizes of deluxe aluminum golf carts. Enter now, while the coupon is right in front of you. Here's all you have to do:

1. Send to Franklin Electric Company, Inc., your name suggestion, which reflects either a use or a feature of the motor. For example: OEM motor, Alumaline motors, etc. Send as many names as you please.
2. Prize winners will be chosen by an impartial panel of judges who are not employees of Franklin Electric Company, Inc.
3. Your entry must be in by February 28, 1961.
4. There's nothing to buy—just send your name suggestion.
5. That's absolutely all there is to it. In addition, your entry will automatically bring you a full-color informative brochure on the new Franklin aluminum motor.
6. Employees of Franklin Electric and its advertising agency are not eligible to participate as contestants. Contest offer not valid in states which prohibit such contests.

SEND YOUR ENTRY TO:
Franklin Electric Company, Inc.
Name-the-Aluminum Motor Contest
Bluffton, Indiana

Name _____	Title _____
Company _____	
Address _____	
City _____	State _____
Suggested name for the new Franklin motor: _____	
D	

Whatever turn shafts may take...

it's easy to match your needs from
LINK-BELT's complete line of
self-aligning ball and roller bearings

High speeds, low speeds—light loads, heavy shock loads, there's a Link-Belt bearing to keep every shaft turning continuously and economically.

Link-Belt's line of ball and roller bearings, the most complete in industry, includes spherical roller bearings, pillow blocks, and flanged, flanged cartridge, cartridge and takeup blocks. All have industry's *preferred* bearing features and all have won the reputation of "the designers' choice."

Link-Belt self-aligning ball and roller bearings compensate for inaccuracies in fabrication and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

Available from local stocks; contact your nearest Link-Belt office. Look under BEARINGS in the yellow pages of your phone book. Ask, too, for Book 2760 and 2550-C containing full information on the complete Link-Belt ball and roller bearing line.

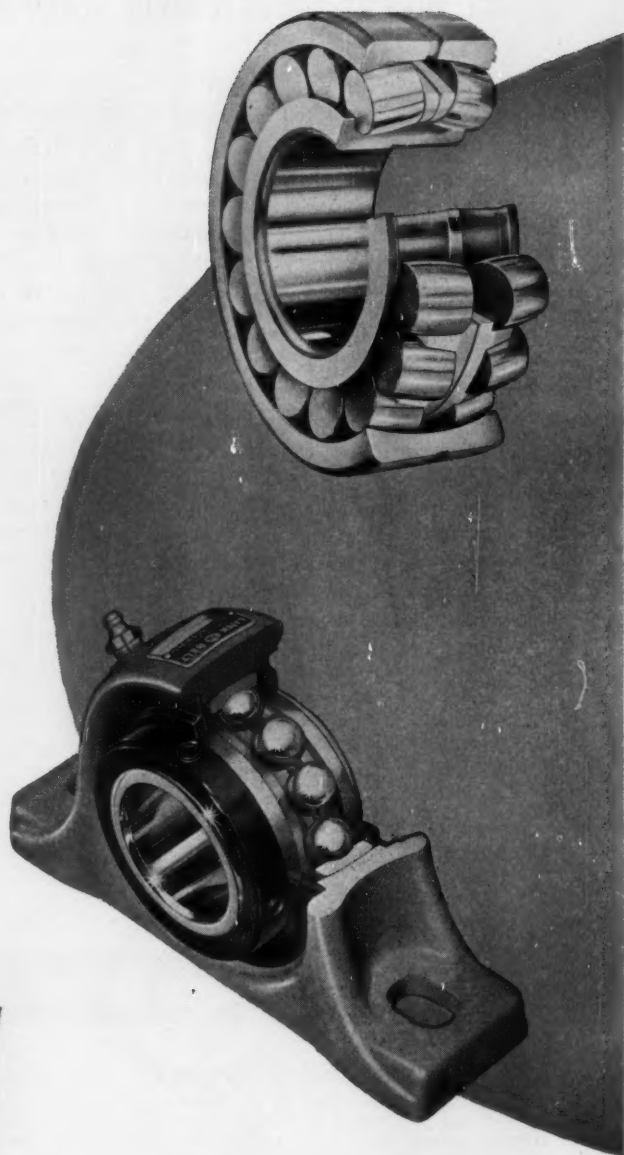


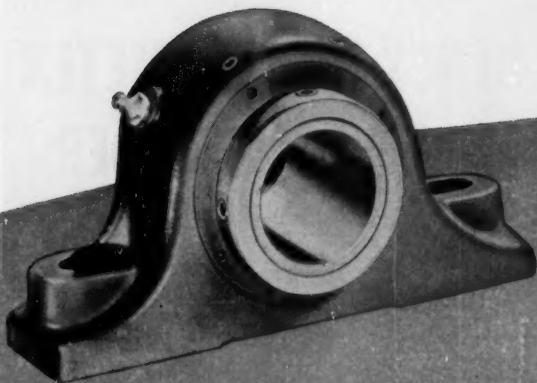
LINK-BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

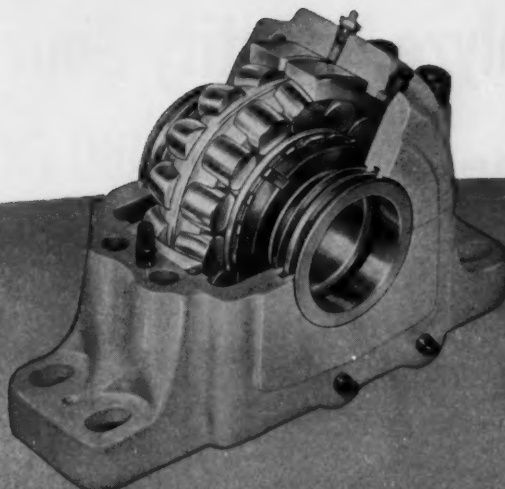
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney) Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

18,413-A





ROLLER BEARINGS WITH SOLID HOUSINGS employ heavy-duty, double-row self-aligning roller bearings. Available with cast iron or cast steel housings. Choice of seals to match operating conditions. Compact, rugged and easy to install. Series 400, for $\frac{3}{4}$ " to 4" shafts.



SPHERICAL ROLLER BEARING PILLOW BLOCKS feature Link-Belt's new Spherical roller bearings in sturdy cast iron or super-rugged cast steel housings. Designed for either adapter or direct shaft mounting. Choice of rugged steel multi-labyrinth or Dacron contact seals. For shafts from $1\frac{1}{4}$ " to 10 $\frac{1}{2}$ ".

NEW SPHERICAL ROLLER BEARINGS combine all the best features of modern bearing design: precision-machined, centrifugally cast bronze retainers; big, highest-capacity rollers; high, heavy inner race flanges. Bearing bores from 40 mm (1.5748") to 220 mm (8.6614").

BALL BEARINGS WITH SOLID HOUSINGS feature self-aligning, single row, deep groove ball bearings. Precision balls operate on honed raceways assuring smooth, quiet operation. Spring locking collars simplify installation . . . lock bearings securely to shaft. One piece housings are compact, require minimum support space. Series 200 and 300, for $\frac{1}{2}$ " to 4" shafts.

**ALSO AVAILABLE
FROM LINK-BELT'S
COMPLETE BALL
AND ROLLER
BEARING LINE**



**FLANGED
BLOCKS**



**CARTRIDGE
BLOCKS**



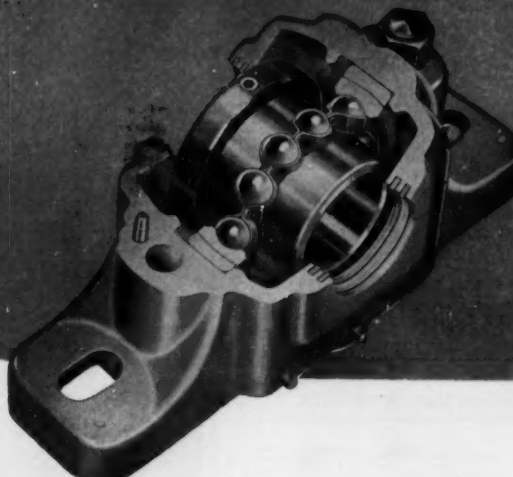
**FLANGED
CARTRIDGE
BLOCKS**



**TAKE-UP
BLOCKS**

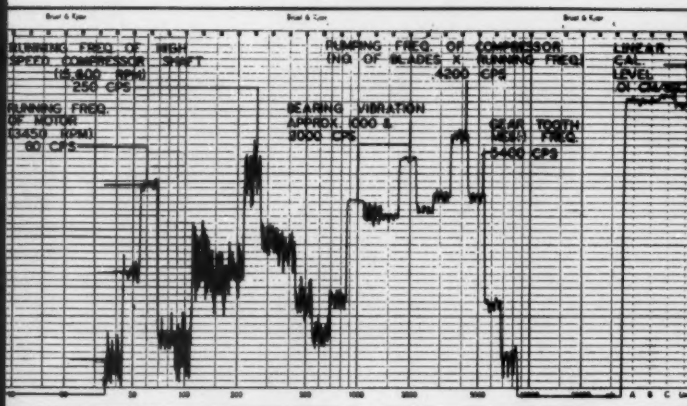
BALL BEARINGS WITH PRESSED STEEL HOUSINGS come completely assembled, ready to install. These low cost, dependable pillow blocks have self-aligning bearings to compensate for mounting inaccuracies. Spring locking collars assure tight fit on shafts. Lubricated for life, these bearings require no maintenance. Series JPS-200, for $\frac{1}{2}$ " to 1 $\frac{1}{2}$ " shafts.

BALL BEARINGS WITH TWO-PIECE HOUSINGS provide ease of installation, simplify bearing and lubricant inspection. Large reservoir for oil or grease makes them ideal for high speed applications. Bearings are self-aligning to compensate for shaft misalignments. Series 200 and 300 for $1\frac{1}{4}$ " to 3 $\frac{1}{4}$ " shafts.



Analyze, Identify Source of Product Noise!

Brüel & Kjær AUDIO FREQUENCY SPECTROMETER and LEVEL RECORDER



The spectrogram shown is a 1/3 octave analysis of the structure borne noise from a large air conditioning unit. The amplitude levels are plotted in true RMS values, an essential to accuracy in such complex signal analysis.

The precise characteristic of the B & K 1/3 octave filters readily distinguishes those frequencies that are the offenders in undesirable noise and vibration.

B & K Model 3312 Spectrum Recorder.
Consists of Model 2111 Spectrometer
and 2305 Level Recorder.

The B & K Model 3312 Spectrum Recorder is a rapid analysis system very well suited to product evaluation. It earmarks pure tones, beat notes and other noise or vibration characteristics, permitting quick identification and determination of those which must be modified or eliminated.

B & K Model 3312 analyzes complex signal frequencies from 14 c/s to 36,000 c/s and voltages from 5 Micro Volts to 1000 Volts.

Gentlemen:
Please send me
☐ B & K Brochure on Model 3312
☐ B & K Complete Line Catalog

Name _____
Company _____
Address _____
City _____ Zone _____ State _____

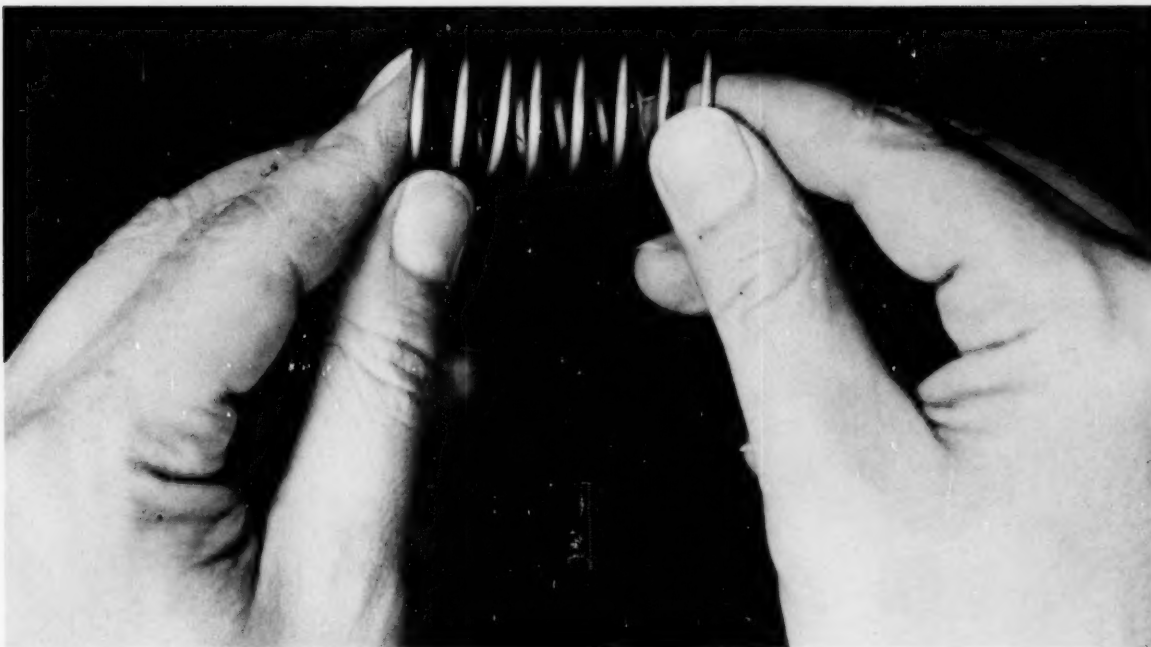


B & K INSTRUMENTS, Inc.

3012 W. 106th STREET • CLEVELAND 11, OHIO • CLEArwater 1-8430



N-S SPRING MATERIAL MAKES THE DIFFERENCE



MUSIC WIRE . . . STAINLESS . . . SUPERALLOY . . . HEAVY GALVANIZED . . . FLAT SPRING STEEL . . . whatever your spring-material needs, **NATIONAL-STANDARD** has a complete line to give you one-source service. Many sizes are stocked for immediate delivery, others can be specially manufactured for 48-hour service, and all are produced with the quality and reliability of fifty-four years of experience. **MUSIC SPRING WIRE:** .002" to .250" diameter. **STAINLESS STEEL SPRING WIRE:** round—.0032" to .125" diameter; flat—.025" to .350" wide, .008" to .100" thick. **HEAVY GALVANIZED SPRING WIRE:** .012" to .060" diameter, 3-7% zinc by weight. **SUPERALLOY SPRING WIRE:** Inconel-X, NS-25 (L605), NS-A286, René 41, 17-7 PH, and others. **FLAT SPRING STEEL:** .001" to .065" thick, .015" to 6.5" wide tempered, .015" to 16" wide untempered.

61-W01A

FOR COMPLETE TECHNICAL DATA ON NS QUALITY SPRING MATERIAL WRITE TO:



NATIONAL-STANDARD COMPANY
Niles, Michigan



NS SPECIAL WIRE WITHSTANDS 1000°F

Landing hot jets like the McDonnell Phantom II at high speeds, means brakes and brake components must be able to withstand extreme temperatures without failure.

A leading manufacturer of brakes for jet aircraft came to National-Standard for help in finding a spring wire that would have high stress-temperature stability up to 1000°F. National-Standard engineers recommended an austenitic superalloy material, NS-A286, recently developed for spring wire applications by National-Standard. Tests showed that NS-A286 met requirements better than any other available alloy, yet cost only half as much as the next best alloy.

SUPERALLOY PASSES TEST—When brakes on the Phantom II are released, the NS-A286 return springs under the brake discs must separate the stationary stator discs from the moving rotor discs. The brake discs build up heat to 1400°F, which is quickly absorbed by the return springs, raising spring temperatures to as much as 1000°F. NS-A286 is a precipitation hardening alloy exhibiting as little as half the relaxation loss at 1000°F as comparable alloys show at 850°F. NS-A286 springs must retain their strength at this heat to separate the brake discs and guard against brake drag during landings.

To test NS-A286, engineers simulated stress-temperature characteristics of three landing conditions.



TO BRAKE JETS

Heat builds up in the brakes in 30 seconds and remains for as long as 20 minutes. The springs must work in the heat against a high back pressure maintained in the aircraft hydraulic system. Springs must be operational for at least 45 normal landings, 5 high-speed, gross weight landings, and one aborted take-off stop, corresponding to stopping the plane just before it becomes airborne. Under all test conditions, NS-A286 met every rigid requirement.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.



NS-A286 SUPERALLOY WIRE, produced by National-Standard, meets critical stress-temperature demands for coaxial return springs in brakes of F4H-1 Phantom II.



Manufacturer of Specialty Wire and Metal Products
NATIONAL-STANDARD COMPANY
Niles, Michigan

PHILADELPHIA REDUCERS keep disaster from Hartford

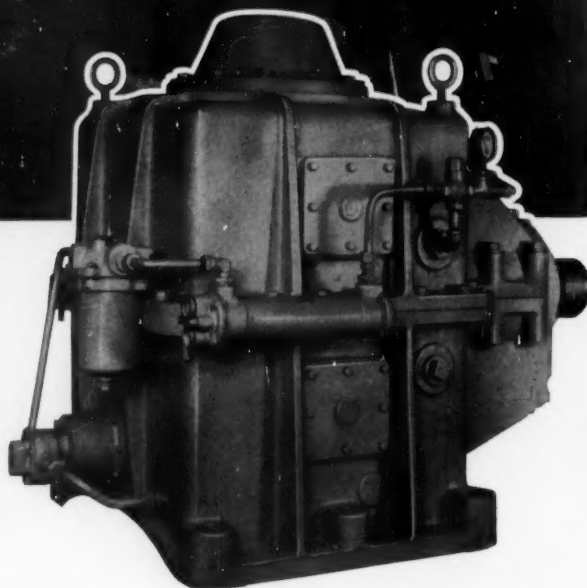


Five miles of dikes protect Hartford, Connecticut against river heights of 45 ft. Yet excess drainage into low lying industrial areas starts at 8-foot levels. Result: pumps operate almost continuously . . . 7 days a week! Seven flood control pumps for Hartford . . . totalling 224,000 gpm . . . are all driven through 450 hp, 1200 rpm Philadelphia Spiral Bevel Reducers.

There are three good reasons why Philadelphia Spiral Bevel Reducers give extra reliability on any continuous, heavy duty job.

1. Spiral bevel gearing is heat treated and hardened after it is cut . . . then lapped to a mirror finish for perfect tooth contact.
2. Heavy-duty bearings and generous bearing spans provide extra rigid mounting and keep bearing loads low.
3. Force feed lubrication. Generous oil reservoir and large radiation surfaces mean cooler running units.

Catalog SB-60 describes our complete line. Write for your copy today.



Philadelphia Spiral Bevel Reducers offer dependable performance with high efficiencies. Housings are fully enclosed, compact and self contained with freedom from oil leakage. Note easy accessibility of oil pump, filter, and cooler.

philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania



Handsome and Hardworking **Plexiglas...Implex**



for Jet Spray Cooler . . . PLEXIGLAS® acrylic plastic is used for sparkling transparent bowls and lids on cold drink dispensers. Bowls and lids are one-piece moldings—crystal clear, breakage-resistant and free from taste or odor. Seven-inch-deep bowls measure 17" by 14".

for Smith-Corona . . . IMPLEX®, the tough, rigid, high-impact acrylic, gives outstanding strength and stain-resistance to vital components of new Galaxie portable typewriters. In addition, the smooth surfaces and lustrous colors of the IMPLEX parts contribute to the typewriter's handsome appearance.

for you . . . PLEXIGLAS and IMPLEX can give your products added utility and sales appeal. Our design staff will be pleased to help you use these Rohm & Haas molding materials—to your advantage.

Chemicals for Industry

**ROHM
&
HAAS**

PHILADELPHIA, PA.



**In Canada: Rohm & Haas Co. of Canada, Ltd.,
West Hill, Ontario**

REPUBLIC HIGH-PERFORMANCE METALS FOR THE HU2K

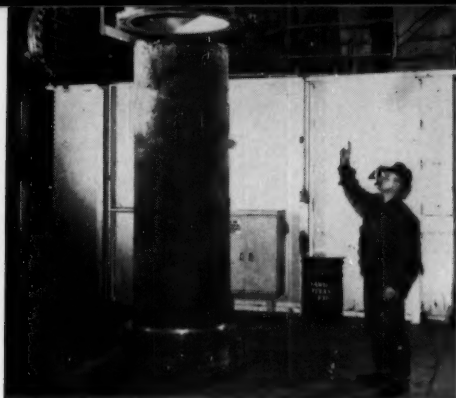
Scheduled for fleet delivery in 1961, the all-weather Kaman HU2K "SEASPRITE" was developed to meet *high-performance* requirements of the U. S. Navy. Working closely with Kaman design engineers, Republic Steel is supplying light gage titanium and stainless steel for the HU2K.

Selected for its resistance to corrosion and abrasion, stainless is used in leading edges of the rotor blades. The titanium—Type RS140—is used in 1½" x 18" strips. Assembled in bundles of 88, these strips are machined into retention straps that are a vital component in the rotor system.

May we help you utilize *high-performance* metals in your project? Republic is the nation's largest producer of alloy and stainless steels, and a major producer of titanium. Republic has the most *extensive vacuum-melting facilities* ever assembled. For complete details, contact your Republic representative or mail the coupon.

Circle 421 on Page 19



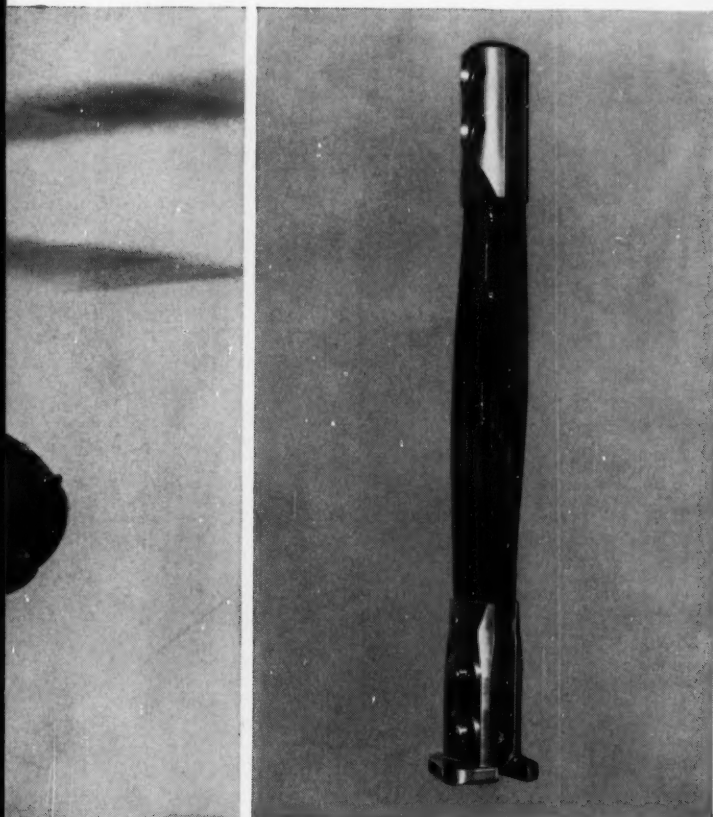


REPUBLIC VACUUM-MELTED METALS are produced in 18- to 32-inch diameter ingots weighing from 4,000 to 20,000 pounds. Vacuum-melted super alloy steels, construction alloy steels, high strength alloy steels, bearing steels, stainless steels, titanium, and special carbon steels are available from Republic in plates, billets, bars, sheets, strip, and wire. Mail coupon for complete information.

Circle 422 on Page 19

3-DIMENSIONAL METALLURGICAL TEAMS: Republic's mill, field, and laboratory metallurgists and machining experts help you select and apply the metal best suited to requirements. Mail coupon for details on this confidential, obligation-free service.

Circle 423 on Page 19

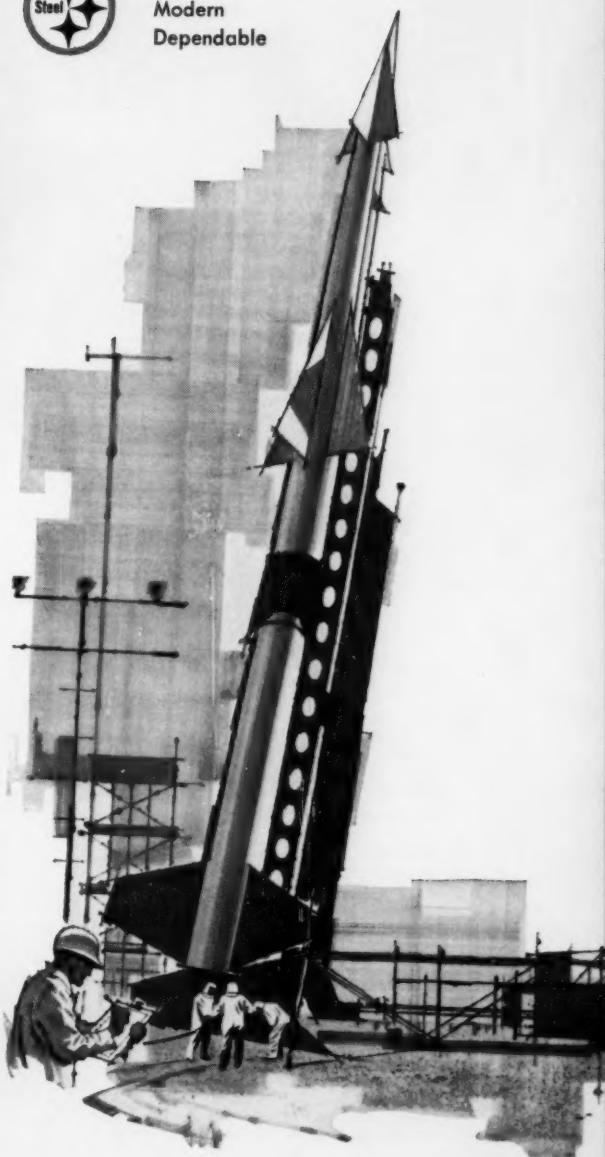


BUNDLED TITANIUM RETENTION STRAPS are designed to work through a torsion angle of $\pm 13^\circ$. Each strap provides a minimum tensile strength of 155,000 psi. The HU2K "SEASPRITE" is manufactured by the Kaman Aircraft Corporation, Bloomfield, Connecticut.

Circle 424 on Page 19



Strong
Modern
Dependable



REPUBLIC STEEL



Where Steels are Made
to Meet the Challenge of Acceleration

REPUBLIC STEEL CORPORATION
DEPT. MD -9656-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

- ☐ Republic Titanium
☐ Stainless Steel
☐ Vacuum-Melted Metals

Have a metallurgist call:

- ☐ Republic Titanium
☐ Stainless Steel
☐ Vacuum-Melted Metals

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____



#8 HONEYCOMB AS A RADIO FREQUENCY NOISE FILTER

The use of metallic honeycomb in attenuating RF noise is an example of honeycomb's unique properties combining to provide several required end results. Honeycomb is extremely effective in this application, not only because of its ability to filter out radio frequency noise, but because it provides an extremely low pressure drop whether directionalizing air flow or merely serving as a grille. In other instances, honeycomb's RF filter properties combine with its light-directional or light-diffusing properties to place the sources of light in a well-lighted test room outside the electrically shielded area. Through correct choice of cell size and cell depth, all properties will operate near optimum levels.

Honeycomb at High and Low Frequencies

Two conditions may be critical in the attenuation of RF noise, although not usually in the same installation. The first concerns energy at the higher frequencies. Here, the cut-off frequency, or maximum frequency at which aluminum honeycomb will effectively block energy radiation, should be well above any frequency actually encountered. The cut-off frequency is a function of the cell size and cell depth of the honeycomb filter. Cell sizes are available in $\frac{1}{4}$ inch and $\frac{3}{8}$ inch in visual-grade honeycomb and down to $\frac{1}{8}$ inch in the less uniform structural grades, with cell depth as great as 24". In practice, the honeycomb most commonly used is a $\frac{1}{4}$ -in. cell with a cell depth of $\frac{1}{2}$ " to 1".

The second critical condition of attenuation is at the low frequency end of the radio noise spectrum. In this area, choice of materials is more limited, since the shielding may require material of higher permeability, such as stainless steel or iron. Correct selection of material, cell size, cell depth and foil gauge, however, will assure effective frequency attenuation.

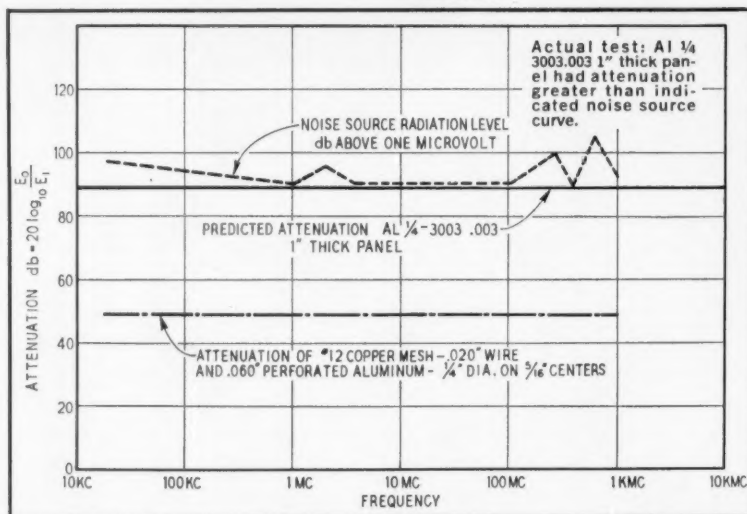
RF Shielding and Light Transmittal

Where light is to be transmitted through an RF shield, the honeycomb filter must first be able to perform its primary electrical function. For signaling devices, where a beam of parallel light is passed through the

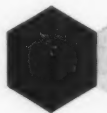
honeycomb louver in a direction parallel to the cell axes, the correct combination of cell size and depth are not critical. For general illumination, however, in a full-lighted ceiling, the ratio of cell depth to cell size must be kept as low as possible, the honeycomb panel must be electrically grounded, and proper finish must be used on the cell walls. The light transmission properties of aluminum honeycomb are primarily a function of the cut-off angle (the angle whose tangent is the ratio of cell depth to cell size), relative position of the honeycomb at light sources, and the reflectance of the floor, walls, and ceiling.

As an example of honeycomb's light transmission properties, a typical Coefficient of Utilization (light transmission efficiency) for a large room would be about .40, assuming the installation of honeycomb with a cell depth of .433 in., cut-off angles of 60° , and optimum plenum conditions. A light level of 100 foot-candles with a Visual Comfort Index of 96 would be quite practicable in this installation. Increasing the cell depth would lower the Coefficient of Utilization, but would give an even higher Visual Comfort Index.

If your design problems could benefit from additional information about the RF shielding and light-directionalizing properties of honeycomb, send for TSB-112, "RF Shielding Properties of Metallic Honeycomb"; HLB-101, "Lighting Properties of Etched HONEYLITE"; and TSB-102, "Air Directional Properties of Honeycomb". Write Dept. 10-C.



Predicted and Actual Attenuation Test



HEXCEL® PRODUCTS INC.

World leader in honeycomb

Executive Offices: 2332 Fourth Street, Berkeley, California

Plants: Oakland and Berkeley, Calif.; Havre de Grace, Md.

Sales Offices: Long Island City, N. Y.; Chicago, Ill.; Fort Worth, Texas; Inglewood, Calif.

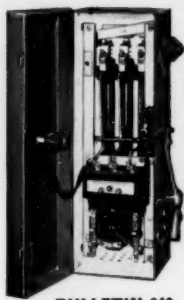
6738

Where Reduced Voltage Motor Starting is Necessary...

Allen-Bradley has the best and most complete answer

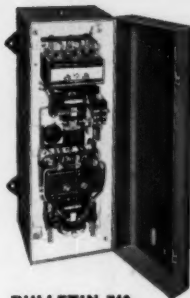
No matter what your reason for reduced voltage motor starting may be, Allen-Bradley has the *right* starter. Not only can the power company's requirements be satisfied exactly, but the A-B starter will at the same time provide the best possible starting conditions for the motor and the driven load. At least one of the starters described below will completely satisfy your operating requirements. For more detailed information, send for Publication 6088.

AUTOMATIC AUTOTRANSFORMER starter for squirrel cage motors that should not be started at full voltage. The autotransformer reduces line voltage during acceleration. Taps permit adjustment of voltage applied to the motor.



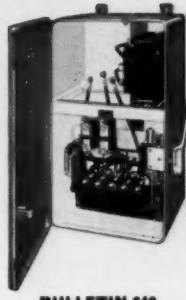
MANUAL STEPLESS RESISTANCE starter has graphite compression disc resistors for velvet smooth starting of squirrel cage motors. Starting of the motor is under the complete control of the operator.

BULLETIN 640



AUTOMATIC RESISTANCE starter has graphite resistors automatically inserted in series with the squirrel cage motor at starting. Resistors can easily be adjusted to motor and load conditions, giving velvet smooth acceleration.

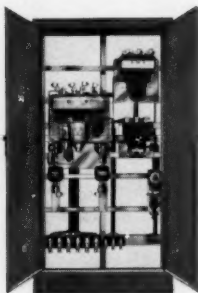
BULLETIN 740



MANUAL AUTO-TRANSFORMER starter for use where load conditions or power company rules require reduced voltage starting. The air break starter shown has double break, silver alloy contacts.

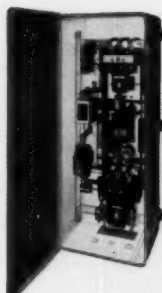
BULLETIN 646

AUTOMATIC MULTIPPOINT RESISTANCE starter for use on network systems. Resistors inserted at starting are cut out in definite steps. Time intervals adjustable to provide velvet smooth starting.



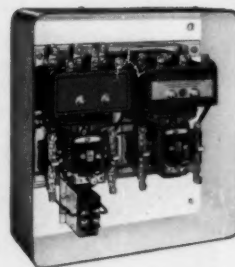
BULLETIN 741

AUTOMATIC STEPLESS RESISTANCE starter is not equalled for velvet smooth motor acceleration. It will satisfy any power company requirement. Eliminates lamp flicker on networks used for power and lighting.



BULLETIN 742

AUTOMATIC PART WINDING starter for use with squirrel cage motors having two separate parallel windings. Made in two-step type, and three-step type with resistance connected in the line on the first step.



BULLETIN 736

3-61-RM

ALLEN-BRADLEY

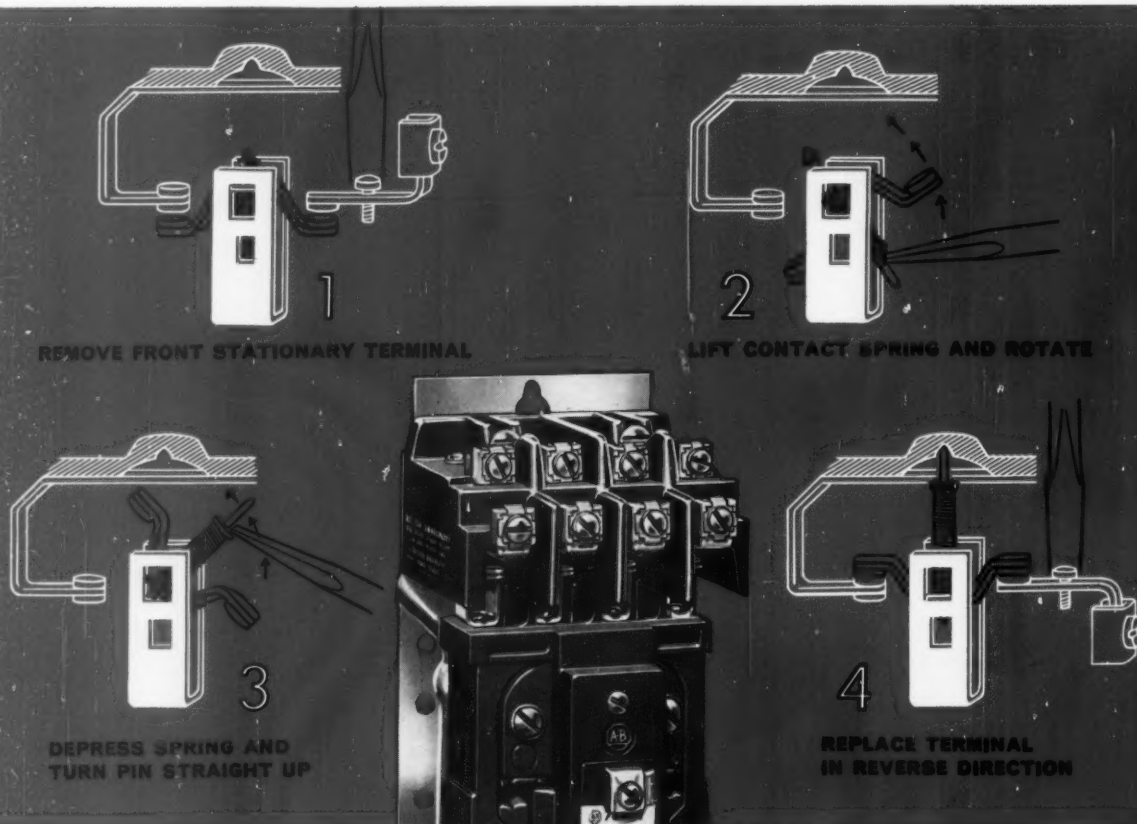
Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

**QUALITY
MOTOR
CONTROL**

Four simple steps to contact changeover

Total time—not more than 60 seconds

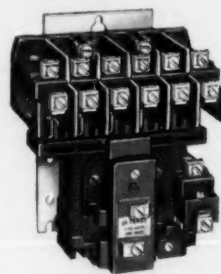
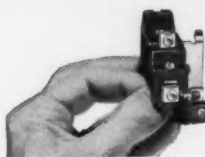


**Converts from
N.O. to N.C. (or vice versa)
in 60 SECONDS!**

You'll be truly amazed at the ease of converting the contacts on these Allen-Bradley Bulletin 700 Type BR relays. Using only a screwdriver, as shown above, the contacts can be changed from N.O. to N.C. (or vice versa) in four easy steps—that take only 60 seconds! Such convenient flexibility is a "natural" for reducing relay inventories.

The Type BR relays are built to provide *many millions* of trouble free operations. With the built-in permanent air gap, magnetic sticking is impossible. And the molded coil is impervious to *all* harmful atmospheres. Of course, the double break, silver contacts *never* need attention. If you use relays, there are money savings for you in the Type BR relay line!

**AUXILIARY
CONTACTS
EASILY ADDED**



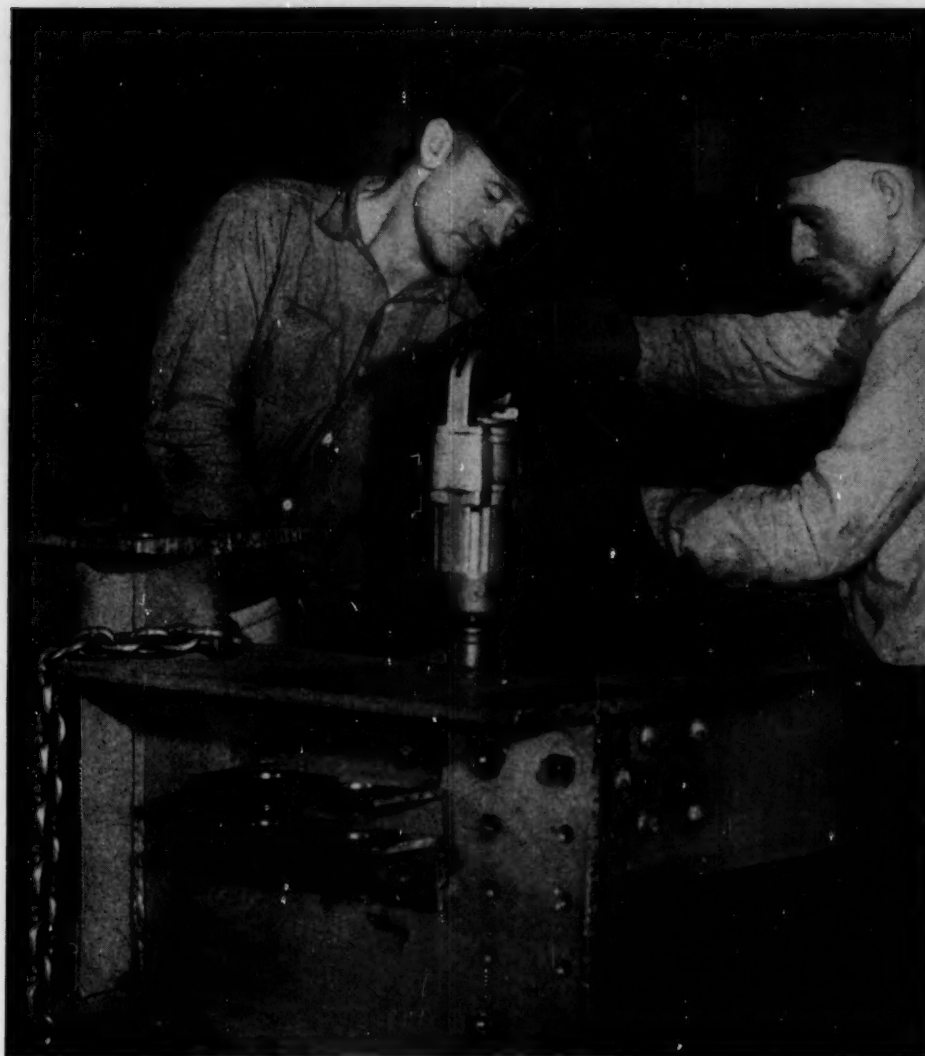
Type BR relays are available with 2, 3, 4, or 6 poles—but as a valuable bonus, one or two fully rated poles can be added to the base of each relay—even in the field. It's a simple addition that takes only moments.

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

**QUALITY
MOTOR
CONTROL**



Strong, tough Nickel alloy steel parts stand up to severe shock as Gardner-Denver impact wrench brings nut-and-bolt assembly up tight as a weld.



Exploded view of Gardner-Denver Model 18B-9 impact wrench reveals vital parts made from AISI 3310 Nickel steel for impact resistance.

Hard-hitting impact wrench lasts longer, thanks to 3½% Nickel alloy steel parts

Each time the socket slams against the faces of a big square or hex nut, seven vital parts of this Gardner-Denver impact wrench sustain the same sharp, powerful blow they deliver.

For built-in resistance to this repeated wear, shock-loading and torsional stress, engineers at Gardner-Denver specify AISI 3310 alloy steel (3½% Nickel) for all seven components that bear the full brunt of this battering:

- Drive assembly
- Cone
- Anvil shaft
- Piston assembly
- Hammer
- Clutch body
- Anvil

All these parts, made from carburized and hardened 3½% Nickel alloy steel, develop a hard, wear-resistant case backed up by a strong, tough core for resistance to countless shocks.

Typical core properties developed by heat-treated AISI 3310 steel:

Tensile strength.....	170,000 psi
Yield point, min.....	140,000 psi
Elongation.....	15% in 2"
Reduction in area.....	60%
Brinell hardness.....	360

When you design, order, or use heavily stressed machine components, remember that Nickel alloy steels take the tough jobs in stride. For engineering data to help you select the best materials for specific applications, just write. We'll be glad to help.

THE INTERNATIONAL NICKEL COMPANY, INC.

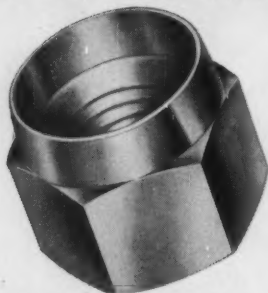
67 Wall Street



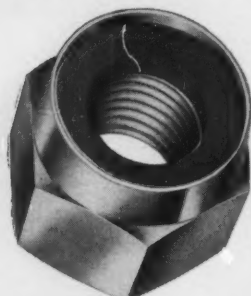
New York 5, N. Y.

INCO NICKEL
NICKEL MAKES STEEL PERFORM BETTER LONGER

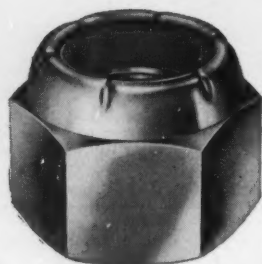
UNSHAKEABLE SELF-LOCKING PERFORMANCE IS BUILT INTO AN ELASTIC STOP NUT



*Start with a standard hex nut
and add a metal crown . . .*



*Add "the ring **O** of reliability"—
the easily identified ESNA red nylon locking insert . . .*



*Then roll the crown over smoothly and stake—
the insert is made an integral part of the Elastic Stop nut*

BUILD FASTENER RELIABILITY INTO YOUR PRODUCT!

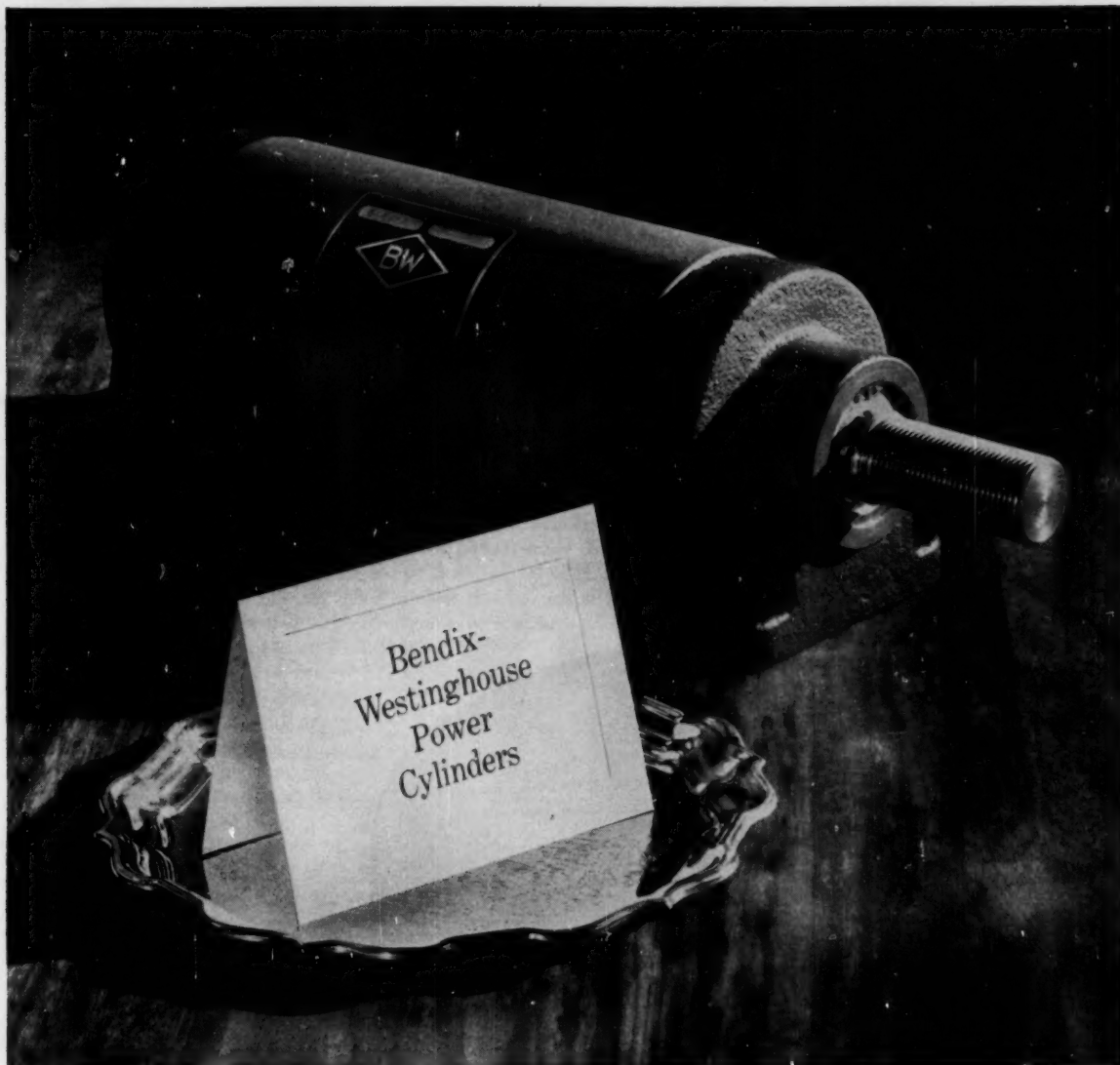
Take an Elastic Stop nut and mount it on one of your products where vibration is really severe. Shake the daylights out of it in the roughest torture test you can devise—or better still—send it into the field where it's subject to regular use and abuse.

Here's what you'll find: That Elastic Stop nut will stay put! The bolt threads are impressed into the nylon locking collar with such a perfect fit that internal liquid seepage is sealed off. Internal nut and bolt threads are protected against corrosion. The nylon insert locking torque is so smooth that it never galls or distorts bolt threads; and nylon is so wear-resistant that under normal usage *you can wrench*

the nut on and off the bolt 50 times or more and the nut will still remain tight under vibration! Protect the performance and the reputation of your product by guaranteeing fastener reliability. Try it yourself and see. Send for free test samples. Just tell us the size. Dept. S53-14, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.



**ELASTIC STOP NUT
CORPORATION OF AMERICA**



Dependable name, dependable product

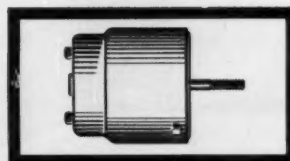
The Bendix-Westinghouse name on a power cylinder is your assurance of dependable performance. And, whatever your application, the wealth of Bendix-Westinghouse design experience permits exact "tailoring" to your needs. Bendix-Westinghouse piston-type power cylinders are widely used in every field of industry, operating up to 200 psi air and 1800 psi oil. Our large inventory of machined parts for standard units, combined with our manufacturing flexibility, means fast delivery to meet your needs. In addition to the broad range of standard models, we also provide many specialized sizes and mounts. When you think of power cylinders, think of Bendix-Westinghouse . . . for dependability! Write today for complete information.

Bendix-Westinghouse

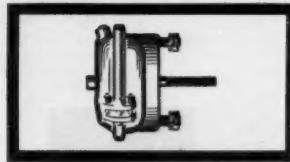


INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 psi air pressure.



ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

MUELLER BRASS CO. PRODUCES

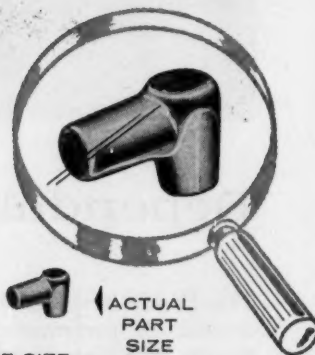
SPECIFICATIONS . . . REGARDLESS OF

To obtain the desired physical and design requirements in a part at the lowest cost, there is usually one specific process by which that part can be most successfully and economically manufactured. Because the Mueller Brass Co. offers a variety of production methods, you get sound engineering, accurate production method analysis, our assurance of getting the best product at the lowest cost . . . regardless of metal specified or the size of your particular part.

BRASS, BRONZE, ALUMINUM FORGINGS

The two parts shown here dramatically illustrate the ability of the Mueller Brass Co. to produce precision forgings regardless of size or configuration. Both the tiny dental drill nozzle and the big heat exchanger shell hub, which is the largest of its kind ever produced, were forged to exacting specifications. The weight of the nozzle is only a few ounces while the shell hub weighs 40 lbs., and has a forged pocket $7\frac{1}{4}$ " in diameter and $4\frac{1}{8}$ " deep. By way of size comparison, the pocket is big enough to hold over 14,000 of these tiny drill nozzles.

By forging the pocket, considerable machining time and money was saved. The sound, dense structure of the shell hub makes it ideal for the high pressure application for which it was designed. The forging not only does the job better, but was produced for 25% less than the casting it replaced. Experience makes it possible for the Mueller Brass Co. to produce high quality precision forgings regardless of specifications . . . why not put this experience to work for you?



Write today for Engineering
Bulletins on any of these Products.



SCREW MACHINE PRODUCTS



POWDERED METAL PARTS

MUELLER BRASS CO.

MACHINE DESIGN

PARTS ECONOMICALLY...TO EXACT

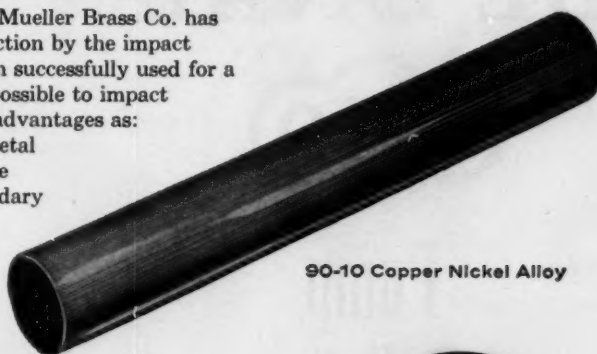
METAL, METHOD OR SIZE...

When you are designing, specifying or purchasing fabricated parts, call in the "Man From Mueller Brass Co." to help lower costs and improve your products. Sales and engineering service is available to you at Mueller Brass Co. offices throughout the United States. Make Mueller Brass Co. your one dependable source for all your part needs.

COLD PREST® IMPACT EXTRUSIONS

Today, because of vast experience in alloys, the Mueller Brass Co. has greatly expanded the possibilities of parts production by the impact extrusion method. Aluminum, of course, has been successfully used for a multitude of tubular shapes. But now it is also possible to impact parts of copper alloys incorporating such major advantages as: closer tolerances, better finish and appreciable metal savings. Because of dimensional accuracy possible with the impact extrusion, the necessity of secondary machining operations is often eliminated.

The parts shown here are representative of the group now being economically produced as impact extrusions by the Mueller Brass Co. who offer complete engineering and design service in the development of new parts from copper base alloys.



90-10 Copper Nickel Alloy



Aluminum Alloy
6061



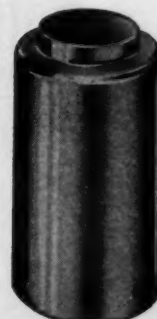
Oxygen Free High
Conductivity Copper



Special Alloy 902



Tellurium Copper Alloy



Low Phosphorus
Copper Alloy

SOURCE FOR ALL THESE OTHER PRODUCTS



FORMED COPPER TUBE



STANDARD and
SPECIAL ALLOY ROD

PORT HURON 20, MICHIGAN



Here's data
on the ideal pump for
design applications

Announcing NEW DE LAVAL IMO Pump Bulletin



New Bulletin 3200 contains all the data you need on De Laval IMO constant-displacement, rotary, screw type pumps. In its pages you will find (1) extensive application data including charts on fuel oil, SAE oil, and turbine oil viscosities; (2) selection information, including specific examples; (3) complete performance data on each IMO model as well as (4) dimension drawings and tables. Write today for your copy of this valuable, 40-page bulletin on the unique IMO pump.



DE LAVAL STEAM TURBINE COMPANY
858 NOTTINGHAM WAY, TRENTON 2, N. J.

DL-2308

Here's why
this should be your brand



because...on the long run...

QUALITY COSTS YOU LESS!

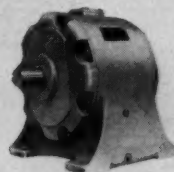
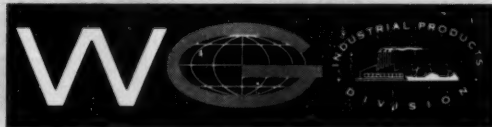
You can't always see quality...many times a second rate piece of machinery can look good. It's on the long run that quality shows up and actually saves you money.

Industry has proved **Western Gear** power transmission drives for 72 years. And Western Gear has cooperated with industry by consistently designing into its drives the features their customers want.

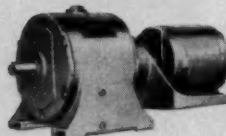
Take reliability, a critical requirement in any power transmission installation: precise gear cutting and finishing techniques and careful heat treatment to uniform hardnesses are unequalled in **Western Gear's** finished drives. This means long life, quiet operation, minimum maintenance and reliable full load performance for you year after year.

Next time you need gear drives for any power transmission application, check the brand that's designed and built to your needs and to your long run requirements... **Western Gear**.

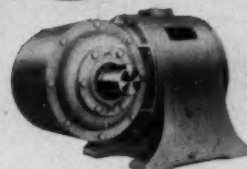
For free catalogs, write to **WESTERN GEAR CORPORATION**, Industrial Products Division, P.O. Box 126, Belmont, California.



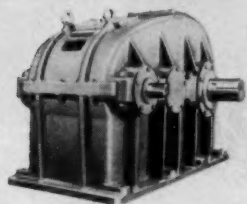
StraitLine
Speed Reducer



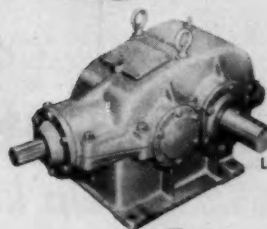
Shovel Base
Horizontal
Gearmotor



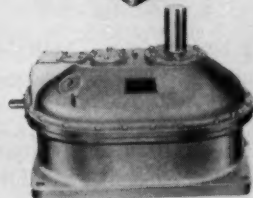
Right Angle
Speed Reducer



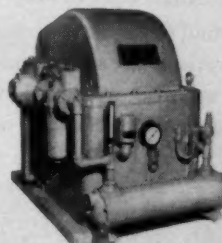
Parallel Shaft
Speed Reducer



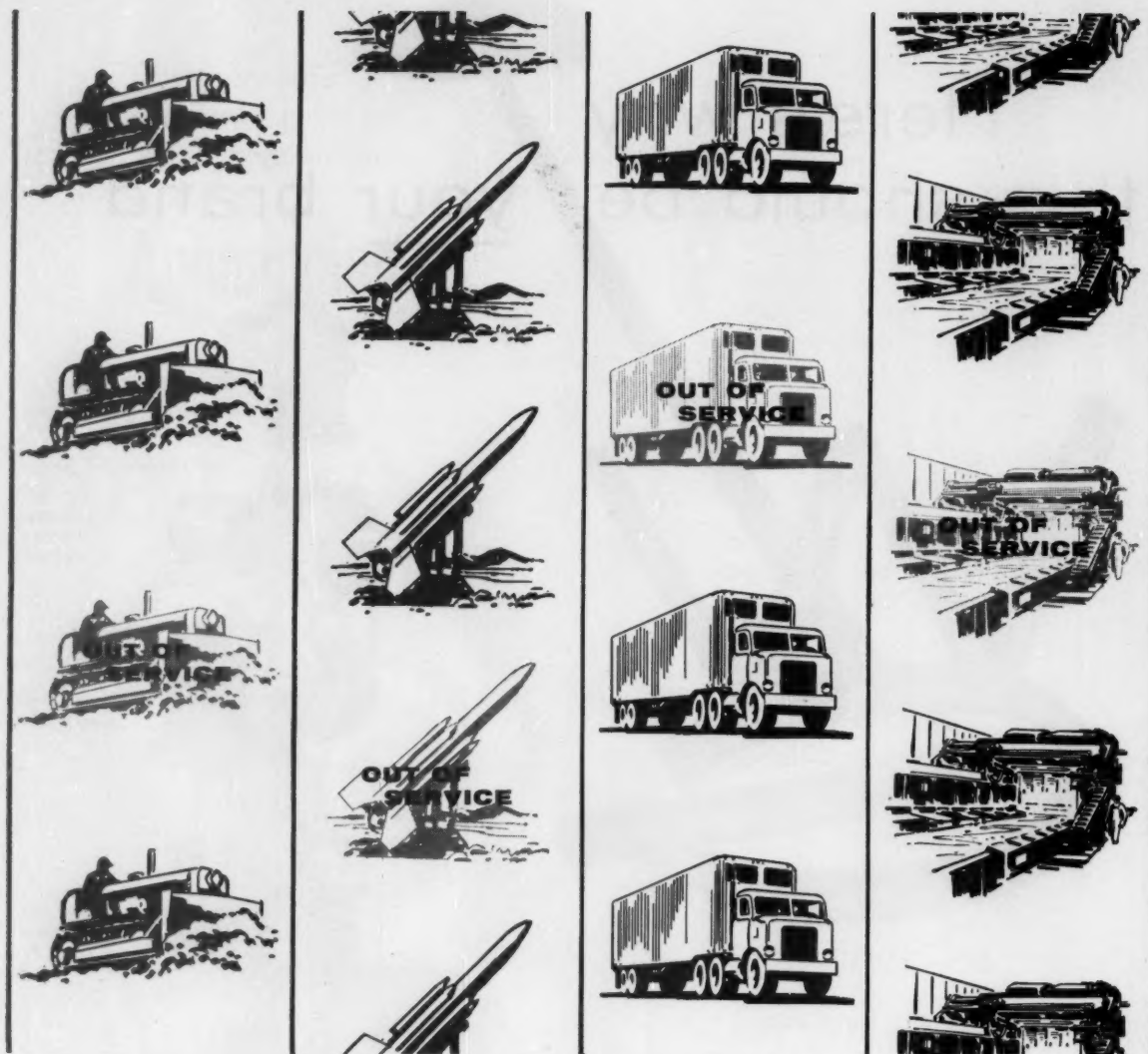
Large Right Angle
Horizontal
Speed Reducer



Large Right Angle
Vertical
Speed Reducer



Small High
Speed Unit



Dependable **ROLLWAY BEARINGS** help keep your down-time low

When a bearing "goes", your machine stops.

That's why it pays to call in Rollway. Especially when reliability is a must.

At Rollway, you can choose from a wide selection of sizes and types with maximum capacities . . . for normal, low or high temperature operation. All meeting or exceeding RBEC requisites in Classes 1 to 5.

You'll find that Rollway meets your needs exactly — in commercial grade, precision, or ultra-precision bearings. To get the bearing you want in a hurry, or to start R and D on the bearing you've been dreaming about, just call or write Rollway Bearing Company, Inc., Syracuse 1, New York.

*Where So Much Depends
on So Little . . .
You can depend on*

**ROLLWAY
BEARINGS**

Radial and Thrust Cylindrical Roller Bearings

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Rolling Back the Heat Barrier

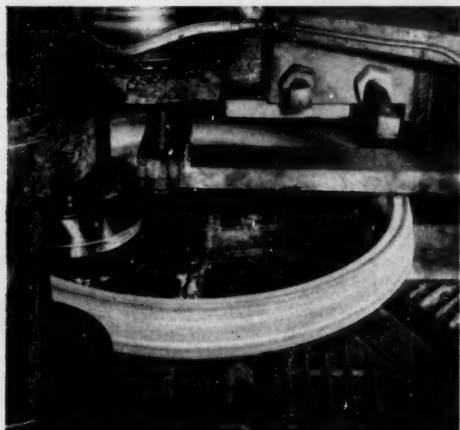
1600

1800

2000

2200

2400



Manufacturer uses ring-roller to shape turbine seal rings made of HASTELLOY alloy X

Address inquiries to Haynes Stellite Company,
270 Park Avenue, New York 17, N. Y.

The surging power of modern 20,000-pound thrust jet engines is being harnessed effectively by critical parts made of HAYNES high-temperature alloys. Turbine seal areas are typical of the hot spots in which these alloys serve. Here, in the form of turbine seal rings, they contain the hot combustion gases as they roar through the various turbine stages.

In these, and in other parts too, such as afterburner liners, flame holders, shrouds, and investment-cast turbine blades and nozzle vanes, HAYNES alloys are resisting the punishing effects of long hours at high temperature. In fact, one of the Air Force's latest 1500-MPH jets uses six different HAYNES alloys in vital parts where heat and stress would weaken and fatigue other materials.

Whether investment- or sand-cast, rolled, wrought, vacuum melted, or air melted, there's a HAYNES high-temperature alloy to meet your needs.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation
Kokomo, Indiana

UNION
CARBIDE

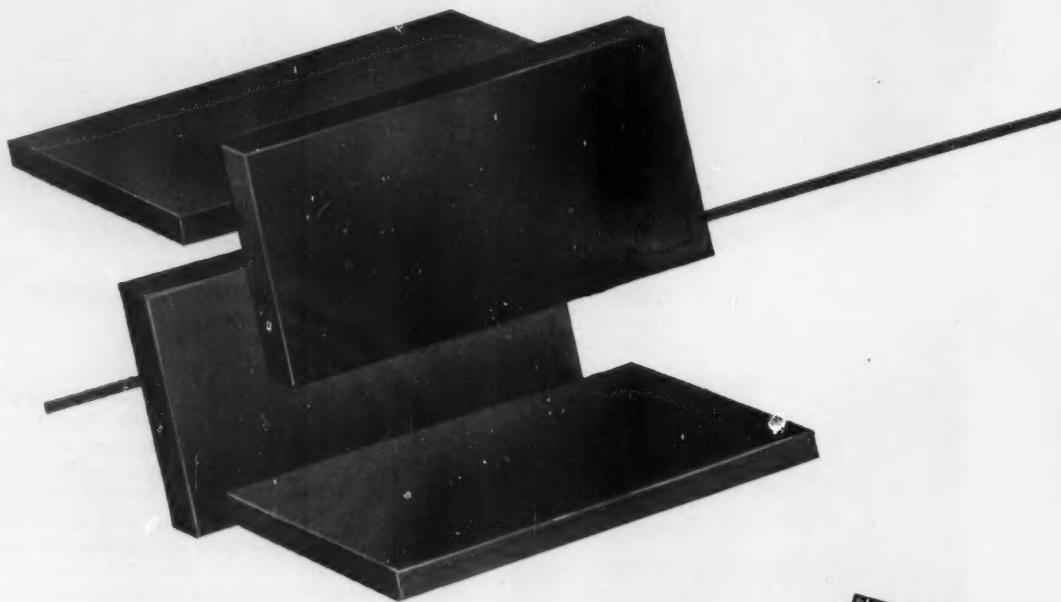
"Haynes," "Hastelloy," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

GRAPHITAR[®] VANES

(CARBON-GRAPHITE)

and long life of CONDE

This rotary positive displacement pump, engineered and produced by the Dri-Air Pump Department of the Conde Milking Machine Company, Inc., of Sherrill, N. Y., is designed to deliver clean, dry air or gas for high vacuum and low pressure applications in hospitals, dental offices, chemical or pharmaceutical plants, industrial processing systems and in metalworking plants. Thanks to vanes of GRAPHITAR, the CONDE Dri-Air Pump gives years of trouble-free, continuous operation at maximum recommended vacuum and speed . . . *without lubrication!* The GRAPHITAR pump vanes are self-lubricating and are seated by centrifugal force. Operating with a minimum of friction, they become increasingly efficient as the pump is used. In addition to their self-lubricating properties, the GRAPHITAR vanes are hard, light, non-sticking, non-warping and chemically inert. Perhaps these qualities can be utilized to advantage in your products.



Bulletin #20 includes detailed design data along with properties, characteristics and typical applications of GRAPHITAR. Write for your free copy. If you have questions concerning the incorporation of GRAPHITAR parts in your products, our engineers will be glad to assist you.

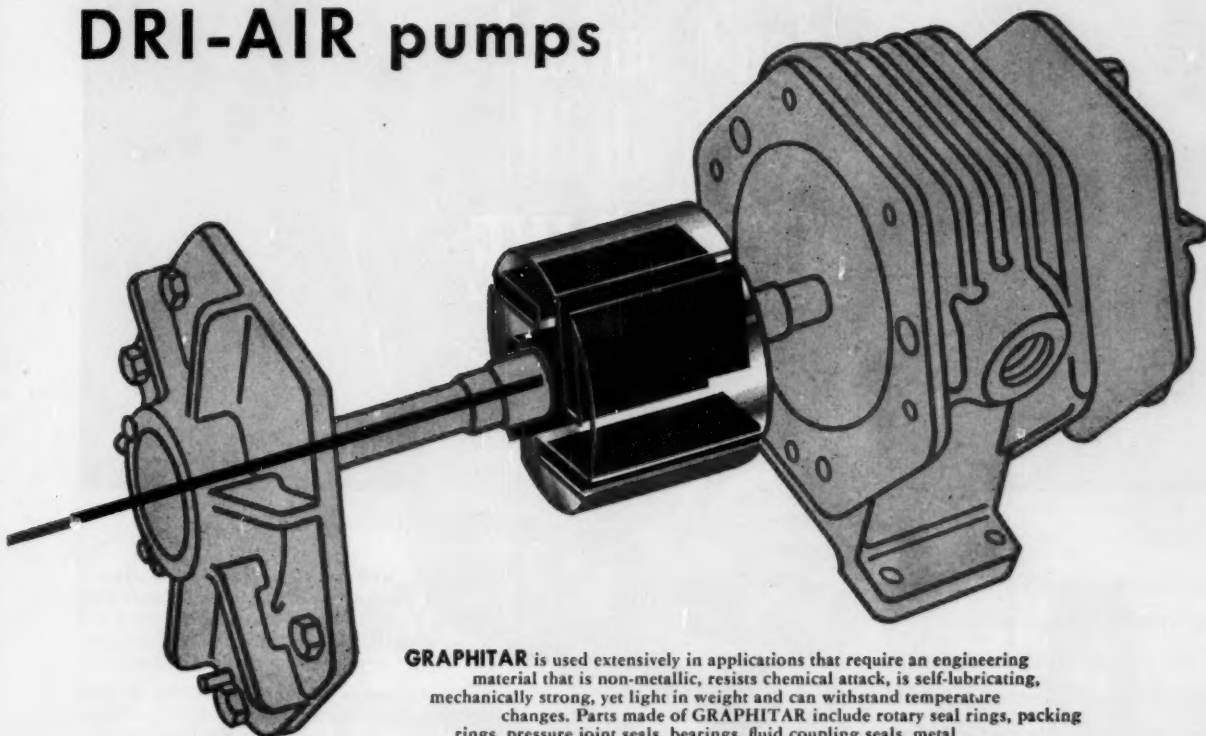


THE UNITED STATES

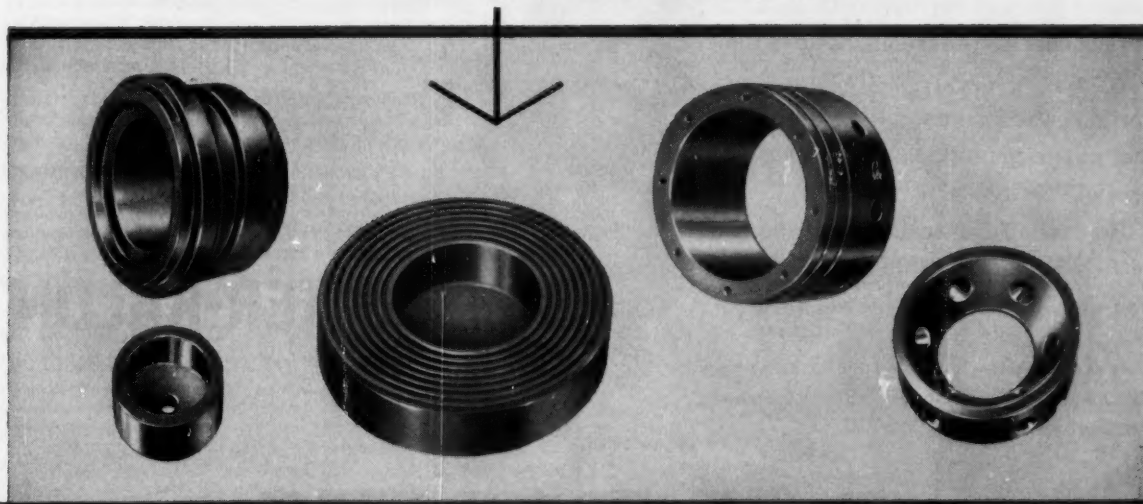
GRAPHITAR[®] CARBON-GRAPHITE • GRAMIX[®] POWDER METALLURGY • MEXICAN[®] GRAPHITE PRODUCTS • USG[®] BRUSHES

help insure efficiency

DRI-AIR pumps



GRAPHITAR is used extensively in applications that require an engineering material that is non-metallic, resists chemical attack, is self-lubricating, mechanically strong, yet light in weight and can withstand temperature changes. Parts made of GRAPHITAR include rotary seal rings, packing rings, pressure joint seals, bearings, fluid coupling seals, metal backed bearings, piston rings and pump liners.



R-285-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

A real self-drilling screw!

don't punch!
don't drill!
JUST DRIVE

P-K Tapits actually *drill* their way into light gage sheets when driven with a power driver! You eliminate hole drilling or punching with this newest idea in tapping screws from Parker-Kalon... speed sheet metal assemblies up to 50%

What's more, P-K Tapits have a serrated washer, integral with the head, that minimizes stripping, by acting as a built-in brake.

Production line tests with millions of P-K Tapits prove these advantages you get with no other screw:

Unique drill point—Tapits start drilling immediately! The cuneiform (pyramid-type) point prevents walking, skidding or creeping!

Uniform Hex Head—Same size hex head on the entire range of Tapits from #6 to #10 means you need only one size driver socket. Sharp corners, well-filled driving faces reduce socket wear.

Advanced washer design—the serrated washer scientifically distributes driving stresses . . . minimizes stripping.

Sharp-crested threads—Holes drilled by P-K Tapits are exactly root diameter. Tapits hold far better because thread in engagement material mates perfectly.

Properly hardened—P-K's exclusive laboratory-controlled hardening and tempering process results in a uniformly hardened screw with a tough core.

USE P-K'S MAGNETIC DRIVER SOCKET FOR POWER DRIVING!

You need only one size driver socket to drive any P-K Tapits! Get the P-K driver socket with a strong Alnico magnet that firmly holds the Tapits. Fits any 1/4" driver with adjustable clutch. Socket can be refaced to extend life.

PARKER-KALON®

originator of the tapping screw

PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey. Offices and warehouses in Chicago and Los Angeles.

P-K® TAPITS

Pat. Pending

TEST P-K TAPITS FOR YOURSELF! ASK YOUR DISTRIBUTOR FOR FREE SAMPLES

50%
MORE TERMINALS
IN THE
SAME SPACE!

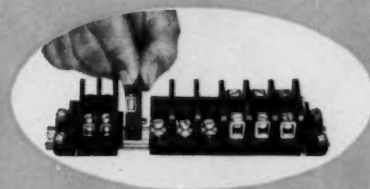
SQUARE D's *NEW* TERMINAL BLOCKS

MORE FLEXIBILITY, TOO!



NEW 12 TERMINALS
CHANNEL-MOUNTED

OLD 8 TERMINALS
ROD-MOUNTED



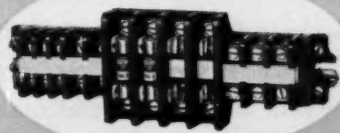
NOTICE (above) how little space is required to remove or add a Square D channel-mounted terminal block to the completely assembled unit. Especially important for a quick change when an additional terminal must be inserted into grouping.

LOOK (at right)...

all sizes can be mounted on same channel...25 ampere pressure wire connectors, 25 to 50 ampere box lugs...all can be interlocked together. Terminals in kit form to "do-it-yourself" or factory-assembled to standard specifications.



NEW...fusible terminal block (below) for protection of solenoids and other single or three-phase loads. Mounts on same channel as regular terminal blocks. Available factory-assembled or in kit form for customer assembly.



ASK YOUR SQUARE D FIELD ENGINEER
or write for Bulletin which covers details on Channel-Mounted Terminal Blocks. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.



SQUARE D COMPANY

wherever electricity is distributed and controlled



*Select from full lines to operate and control a single OEM product
... or a plant's entire production line!*

Modern manufacturing demands quality ... and Schrader Valves have it. Complete lines give you almost limitless range in planning air circuitry. The many extras in all Schrader Valves ... superb engineering, compactness, strength, easy installation ... make for precision operation. Your Schrader distributor is fully stocked, not only with Valves, but Cylinders and Accessories. He can help you with factory-trained experts and proven ideas.



The complete range of sizes and types of air circuitry products is stocked and cataloged by your Schrader distributor. Consult the yellow pages or write Schrader.



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Division of Scovill Manufacturing Company, Incorporated
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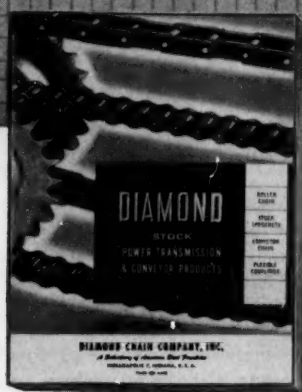
QUALITY AIR CONTROL PRODUCTS

Here's what **DIAMOND** Roller Chain's
HIGHER HORSEPOWER RATINGS
mean to you...

**GREATER
CAPACITY**

**LONGER
LIFE**

**LOWER
COSTS**



**Write for New DIAMOND
CATALOG No. 760**

Just off the press. DIAMOND Stock Roller Chain, Sprocket, and Coupling Catalog No. 760 gives all the new horsepower ratings. Catalog 760 also contains full data on four important new DIAMOND Roller Chain Products: *Micropitch*, *Dura-Weld* and *Tuf-Flex* chains and *Hi-Cap* flexible couplings.

For Example:

Former ratings for 1 inch pitch roller chain permitted sprocket speeds up to 1160 RPM, whereas the *new* ratings include speeds up to 2800 RPM. Similarly, rated *horsepower* capacities formerly did not exceed 49 HP, whereas the new ratings exceed 150 HP. New, higher ratings mean that DIAMOND roller chains are capable of more work, will last longer (thus, cost less to operate) than heretofore considered practical. You now have more opportunities to specify high-efficiency DIAMOND Roller Chain drives... both in new equipment designs and in modifications of existing equipment. Write today for *new* DIAMOND Catalog No. 760. *It contains all the new ratings* as established by the Association of Roller and Silent Chain Manufacturers, of which DIAMOND is a charter member.

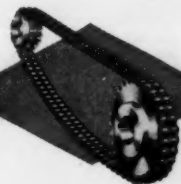
DIAMOND CHAIN COMPANY, INC.

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DIAMOND

**ROLLER
CHAINS**





Lee Alspaugh, Maintenance Foreman, Carlisle Tire & Rubber Co., says that Micro-Fog Lubrication has proved ideal for the bearings and gears on this warm-up mill.



Norgren Micro-Fog Lubro-Control Unit

Norgren Micro-Fog improves lubrication on heavy machinery at Carlisle Tire & Rubber

...minimizes housekeeping problems

At Carlisle Tire and Rubber Division of Carlisle Corporation, Carlisle, Pennsylvania, drip-feed oilers proved unsatisfactory for lubricating the gears and bearings of warm-up mills. Early in 1959, a Norgren Micro-Fog Lubro-Control Unit was installed on one of the mills. The unit lubricates the bearings for the 5' long, 20" and 22" diameter rolls. It also lubricates the gears—a 63" pitch diameter 12" face bull gear with a 16" pitch diameter 12½" face pinion.

The Norgren Unit automatically and continuously applies an exactly metered amount of fresh, clean oil to each bearing and gear.

Carlisle reports that bearings run cooler and quieter, and wear on gears and bearings is now at a minimum. Less lubricant is needed, servicing is quicker, and messy housekeeping conditions around the machine have been eliminated. As a result, Carlisle is converting other critical machines in the plant to Micro-Fog lubrication.

FOUNDED IN 1926

C. A. NORNGREN CO.

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

Norgren Micro-Fog Lubrication gives you these money-saving benefits:

1. Automatic, continuous lubrication in exactly metered amounts
2. Better lubrication—less machine downtime.
3. Lubrication for all types and sizes of bearings, and for gears, chains and ways.
4. Fewer service points—centralized lubrication.
5. Lower bearing temperatures.
6. Longer bearing and gear life.
7. Lower costs for lubrication maintenance.
8. Low lubricant consumption—lower cost for lubricant.
9. Elimination of product contamination by lubricant.
10. Elimination of fire and safety hazards from dripping lubricant.
11. Visible oil feed.
12. Elimination of many oil seals.
13. Oil always fresh and clean—no recirculation.
14. Elimination of oil filters, sumps and pumps.

For complete information about how Norgren Micro-Fog Lubrication can make big savings in your plant, call your nearby Norgren Representative, listed in your telephone directory—or WRITE FOR DESCRIPTIVE LITERATURE.

Aggregates and cement are delivered by **JEFFREY CONVEYORS** in a new mobile concrete batching plant



Self-erect, mobile concrete batching plant by Heltzel Steel Form & Iron Company of Warren, Ohio, in operating position at batching site.



CARL HELTZEL, President

In designing and building this revolutionary mobile plant, our engineers created a unit to fill a long felt need in the construction industry. To achieve efficient operation, we relied on Jeffrey's close cooperation in providing us with quality components equal to the rugged job to be done.

The new Heltzel mobile plant produces 130 cubic yards of weigh-blended dry material an hour in increments of 7-½ cubic yard batches. When rigged for over-the-road travel, its transport height is only 12'6" and its width only 10'. At the construction site, a self-contained hydraulic mechanism lifts the plant into operating position. The conveyor belts lower to the ground to receive aggregates from

ground storage hoppers and, in the same operation, the batcher is elevated to proper height for charging dry batch into transit mix trucks.

Three 18" belt conveyors traveling on Jeffrey belt idlers carry aggregate and sand to the weigh hoppers at a capacity of 500 tons per hour. Dry cement is drawn from the storage bin body of the plant and lifted to the batcher by Jeffrey screw flights operating at a 40° angle. Water is proportioned into the truck by a preset automatic water meter.

Heltzel engineers rely on the assistance and co-operation provided by Jeffrey materials handling engineers in selecting materials handling components. For similar assistance, contact The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

Conveying • Processing • Mining Equipment
Transmission Machinery • Contract Manufacturing

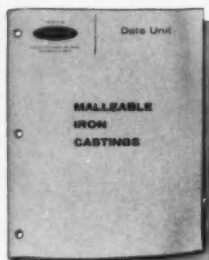


New Cars and Trucks Use More Malleable For Better Performance...Lower Cost

As the automotive industry steps up its drive to pack greater performance into lighter weight vehicles and still hold costs in line, the demand for Malleable iron castings continues to increase. Noted for their strength, toughness, machinability and economy, Malleables are used as key components in every make and type of vehicle.

Matching each new advance in automotive technology, Malleable is now available in a broad range of properties, including tensile strengths from 50,000 to 120,000 psi!

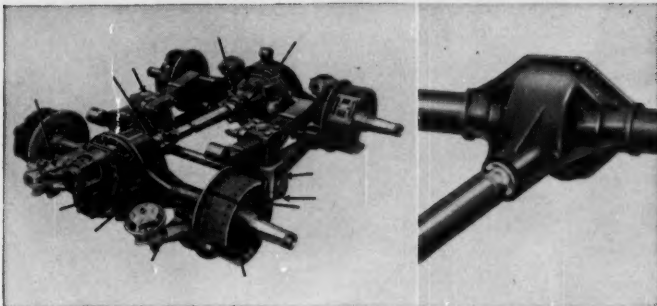
Find out now how much Malleable castings can improve your products. Contact any company that displays this symbol —



For Free Literature on advantages of Malleable iron castings, with examples from the automotive industry, ask any member company for Data Unit No. 113, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.



Testifying to Malleable's outstanding ability, pearlitic Malleable iron crankshafts are now used in both cars and trucks, like this new heavy-duty highway hauler. Pearlitic Malleable was chosen for its high strength, wear resistance, damping capacity and machinability... Malleable is the most machinable of all ferrous metals of similar properties.



From the smallest cars to the largest trucks, all American vehicles rely on Malleable for a range of uses. In this tandem axle, for example, a total of 36 parts is Malleable.

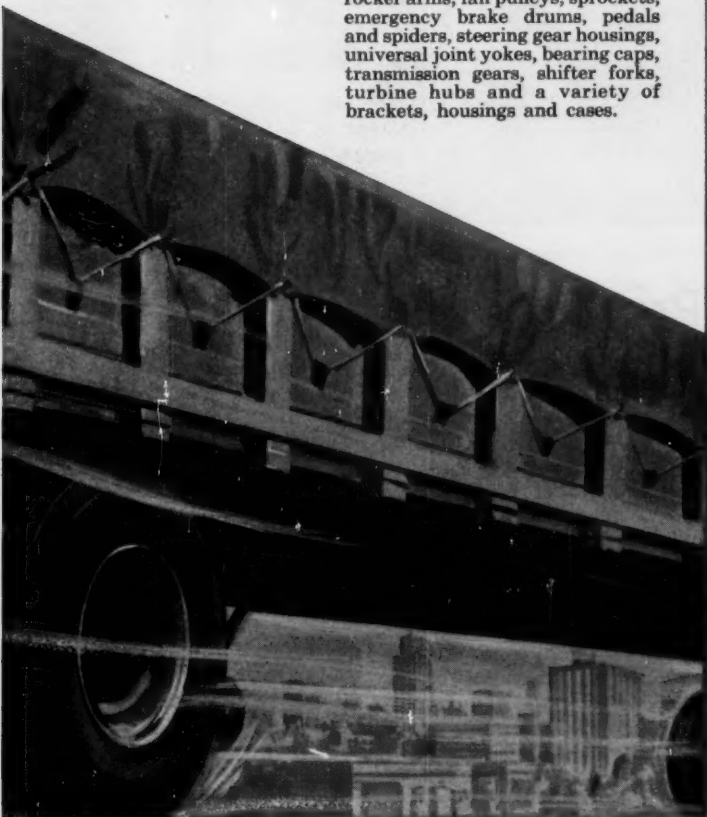
Malleable differential carriers form the backbone of the rear axles on many new compact cars, as shown at the right above. Tubular steel extensions are pressed into the Malleable housing where they are "puddle" welded. Decisive factors in Malleable's selection were strength, economy, ease of machining and ability to be produced in a design that required a minimum of tooling expense.



The increasing conversion from other materials to Malleable castings for all kinds of parts from crankshafts to door hinges is adding momentum to the automotive

industry's steadily increasing use of Malleable.

Among the many Malleable iron castings in this composite car are torsion bar arms and brackets, rocker arms, fan pulleys, sprockets, emergency brake drums, pedals and spiders, steering gear housings, universal joint yokes, bearing caps, transmission gears, shifter forks, turbine hubs and a variety of brackets, housings and cases.



**For
Quality
and
Economy
Use**

MALLEABLE

For Service Contact...

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Eastern Malleable Iron Co., Naugatuck

DELAWARE

Eastern Malleable Iron Co., Wilmington 99

ILLINOIS

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Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Mail and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA

Albion Malleable Iron Company,
Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mail & Steel Castings Co., Indianapolis 22

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Dayton Mail. Iron Co., Ohio Mail. Div., Columbus 16
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Chain Belt Company, Milwaukee 1
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Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

**These companies are members
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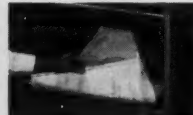
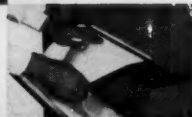


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A. Operator inserts microfilm aperture card.

B. Next, inserts sheet of ordinary paper, vellum, or offset paper master. Insertion starts automatic printing and processing cycle.



C. First print is automatically delivered in 30 seconds; subsequent prints (of the same or different drawings) every 15 seconds.

The Copyflo® 1824 Printer, using ordinary paper, cuts costs of engineering-drawing reproduction

Here's a remarkable machine that sharply reduces the cost of engineering-drawing reproduction because it *uses ordinary, inexpensive paper*.

The XeroX® Copyflo® 1824 printer, which requires no exposure or other adjustment, reproduces from a microfilm aperture card, making dry, positive, 18" x 24" prints—or smaller—at extremely low cost. It also copies onto vellum or offset paper masters.

Operation is automatic. Prints ready for immediate use emerge as fast as four a minute.

The quality of reproduction is superb. Images are sharp black-on-white and won't rub off. There is no odor,

no waste, and the finished print may be written on with pen or pencil.

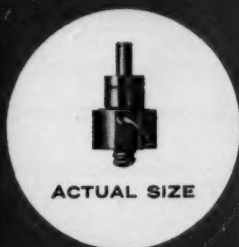
Regardless of your engineering-drawing-reproduction needs, you can now enjoy the tremendous savings in time, money, space, and materials of your own unitized microfilm system.

Formerly, such economies required a substantial reproduction need. Today, however, the Copyflo 1824 printer offers the same proportionate benefit to small-volume users as to large. No need now for vast files of engineering drawings. Microfilm aperture cards require only a fraction of the storage space required for other reproduces. No more costly waiting for

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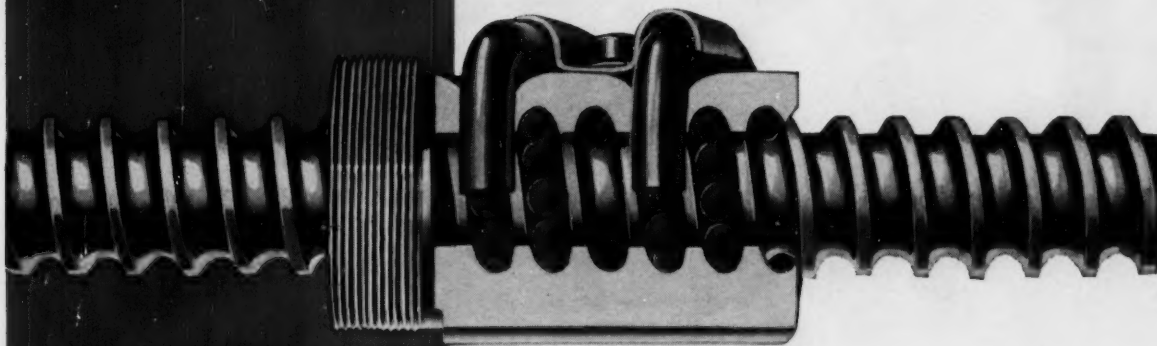
Write today for our free 1824 booklet giving the full benefits you can expect from a Copyflo 1824 printer. HALOID XEROX Inc., 61-168X Haloid St., Rochester 3, N.Y. Branch offices in principal U.S. and Canadian cities. Overseas: Rank Xerox Ltd., London.

HALOID XEROX®



MINIATURE Small enough to rest on the head of a tack, the newest and tiniest Saginaw b/b Screw is only $\frac{3}{4}$ of an inch long, has a B.C.D. of just $\frac{1}{16}$ ths of an inch. It solves positioning/control problems in telemetering and guidance systems and other diminutive applications.

GIANT-SIZED Giant Saginaw b/b Screws, built as large as 6 inches B.C.D. and as long as 40 feet, are used in applications where size reaches gigantic proportions. Proof of their versatile adaptability, Saginaw b/b Screws are used in boom hoists, telescoping blimp mooring masts and other applications.



SAGINAW ^{ball/bearing} SCREWS CARRY YOUR PRODUCT'S SUPERIORITY FURTHER!

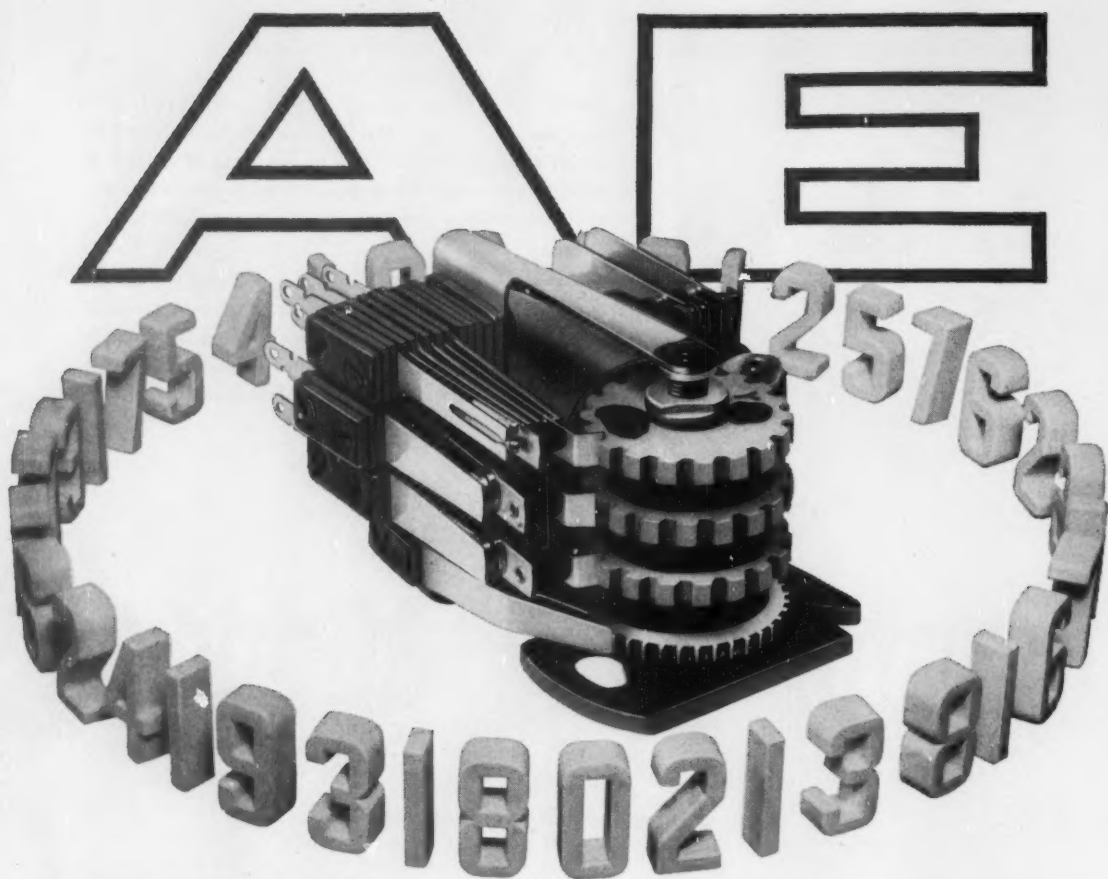
The men who want to increase their product's maximum potential specify the remarkable Saginaw Screw for its many advantages. The 90%-plus efficiency of actuators using the ball bearing screw principle lowers operating costs, requires far less maintenance, simplifies design, in many instances reduces installation costs. Saginaw Screws are adaptable to electrical, hydraulic, mechanical or pneumatic operation. Their length and ball circle diameters can be built to almost any size. Their dependability and accuracy can improve your product's function and help make it more competitive!



WRITE TODAY FOR Saginaw's new 1961 fact-filled Engineering Data Book.

Saginaw
^{ball/bearing} **Screw**

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS CORP., SAGINAW, MICH.



TO THE ENGINEER

who can't tolerate a lapse of memory

If you're working on a think machine that can't afford to break its train of thought, consider AE's pint-size, fast-stepping OCS switcher. Unlike electron tubes and relays, this sophisticated device won't lose stored memory in the event of power failure or circuit interruption.

Besides, it can do the work normally assigned to whole banks of relays.

The AE Series OCS will follow or initiate a prescribed series of events or cycles at 30 steps per second impulse-controlled, or 65 steps per second self-interrupted. Any programming sequence can be set up on one to six cams with as many as 36 on-and-off steps

per cam. And each cam will actuate as many as six contact springs.

In any event, if your designs involve relays or stepping switches, AE circuit engineers may be able to save you a pretty penny. Or, if you'd like to leave the switching to us, we're equipped to supply prewired and assembled, custom-built control units, or help you develop complete control systems.

To explore the matter, just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1698-H: *Rotary Stepping Switches*; Circular 1702-E: *Relays for Industry*; and our new 32-page booklet on *Basic Circuits*.

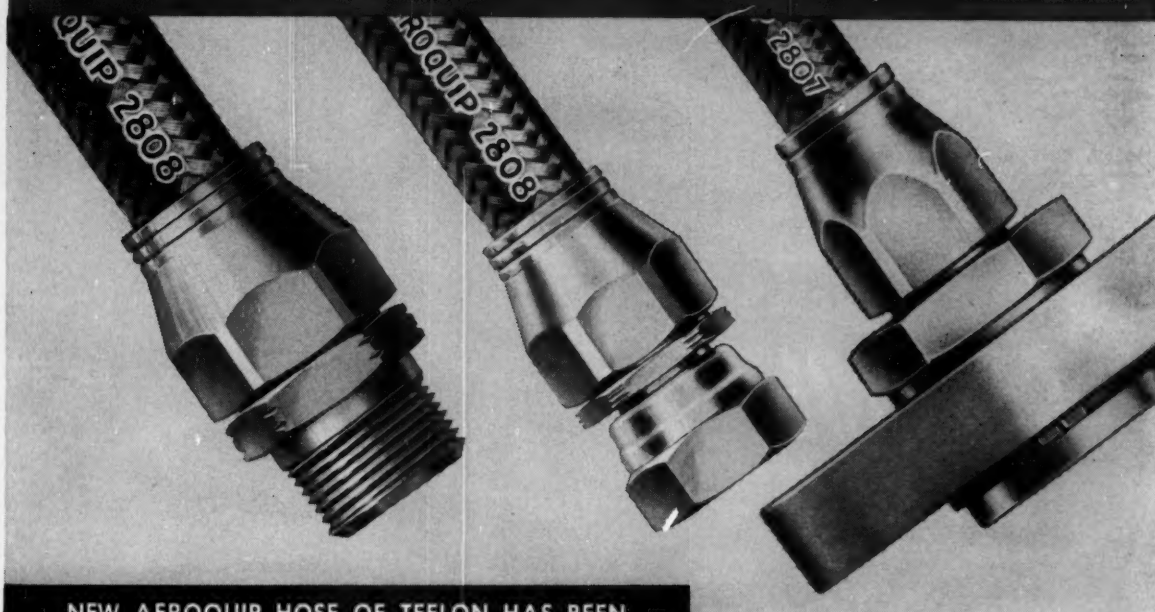


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Solve Steam and Chemical Transfer Problems

WITH THESE NEW AEROQUIP HOSE LINES OF TEFLON



NEW AEROQUIP HOSE OF TEFLON HAS BEEN APPROVED FOR USE WITH THESE FLUIDS:

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<input checked="" type="checkbox"/> Acetic Acid	<input checked="" type="checkbox"/> Carbon Dioxide (Dry)	<input checked="" type="checkbox"/> Hexane	<input checked="" type="checkbox"/> Oleic Acid
<input checked="" type="checkbox"/> Acetone	<input checked="" type="checkbox"/> Carbonic Acid	<input checked="" type="checkbox"/> Hydraulic Fluids (Natural & Synthetic)	<input checked="" type="checkbox"/> Oxalic Acid
<input checked="" type="checkbox"/> Acetylene	<input checked="" type="checkbox"/> Carbon Disulphide	<input checked="" type="checkbox"/> Hydrochloric Acid	<input checked="" type="checkbox"/> Paints & Varnish
<input checked="" type="checkbox"/> Air (Hot)	<input checked="" type="checkbox"/> Chlorinated Solvents	<input checked="" type="checkbox"/> Hydrocyanic Acid	<input checked="" type="checkbox"/> Petroleum Oils (Sour & Refined)
<input checked="" type="checkbox"/> Alcohols (Aliphatic & Aromatic)	<input checked="" type="checkbox"/> Creosote Oil	<input checked="" type="checkbox"/> Hydrofluoric Acid	<input checked="" type="checkbox"/> Phosphoric Acid (Commercial)
<input checked="" type="checkbox"/> Alkaline Solutions (Hydroxides)	<input checked="" type="checkbox"/> Chromic Acid	<input checked="" type="checkbox"/> Hydrogen Peroxide (Dilute & Conc.)	<input checked="" type="checkbox"/> Potassium Salt Solutions
<input checked="" type="checkbox"/> Aluminum Salt Solutions	<input checked="" type="checkbox"/> Copper Salt Solutions	<input checked="" type="checkbox"/> Hydrogen Sulfide (Wet & Dry)	<input checked="" type="checkbox"/> Sodium Salt Solutions
<input checked="" type="checkbox"/> Ammonia (Aqueous)	<input checked="" type="checkbox"/> Ethers	<input checked="" type="checkbox"/> Hypochlorite Solutions	<input checked="" type="checkbox"/> Steam
<input checked="" type="checkbox"/> Ammonia Salt Solutions	<input checked="" type="checkbox"/> Ethylene Glycol	<input checked="" type="checkbox"/> Lacquers, Lacquer Solvents	<input checked="" type="checkbox"/> Sulfur Dioxide (Wet & Dry)
<input checked="" type="checkbox"/> Aniline Dyes & Oils	<input checked="" type="checkbox"/> Ethylene Dichloride	<input checked="" type="checkbox"/> Lube Oil (Hot & Cold)	<input checked="" type="checkbox"/> Sulfuric Acid
<input checked="" type="checkbox"/> Asphalt	<input checked="" type="checkbox"/> Ferric Salt Solutions	<input checked="" type="checkbox"/> Magnesium Salt Solutions	<input checked="" type="checkbox"/> Sulfurous Acid
<input checked="" type="checkbox"/> Benzene (Benzol)	<input checked="" type="checkbox"/> Formaldehyde	<input checked="" type="checkbox"/> Mercuric Chloride	<input checked="" type="checkbox"/> Tannic Acid
<input checked="" type="checkbox"/> Bromine	<input checked="" type="checkbox"/> Formic Acid	<input checked="" type="checkbox"/> Mercury	<input checked="" type="checkbox"/> Toluene (Toluol)
<input checked="" type="checkbox"/> Butylene	<input checked="" type="checkbox"/> Furfural	<input checked="" type="checkbox"/> Mineral Oil	<input checked="" type="checkbox"/> Trichlorethylene
<input checked="" type="checkbox"/> Calcium Hypochlorite	<input checked="" type="checkbox"/> Refrigerant 12 & 22	<input checked="" type="checkbox"/> Naphtha	<input checked="" type="checkbox"/> Water (Salt & Fresh)
<input checked="" type="checkbox"/> Calcium Salt Solutions	<input checked="" type="checkbox"/> Glycerin (Glycerol)	<input checked="" type="checkbox"/> Naphthalene	<input checked="" type="checkbox"/> Zinc Salt Solutions

As the chart at left indicates, Aeroquip's new, lightweight 2807 and 2808 Hose Lines of Teflon convey steam and practically any chemical, acid or solvent. Chemically inert, Aeroquip Hose of Teflon resists corrosion, contamination and adhesion and provides exceptionally long, trouble-free service, even where constant flexing and vibration occur. The new lightweight construction extends the practical use of Aeroquip Hose of Teflon and costs less compared to ordinary Teflon hose. Operating temperature limits are -100°F. to $+450^{\circ}\text{F.}$ In sizes for $\frac{1}{4}$ " to $1\frac{1}{4}$ " lines, for pressures up to 1500 psi.

New, lightweight "super gem" Fittings also help reduce hose line costs. They not only cost less, but they can be disassembled and reused over and over again. Fitting styles available include male pipe, J.I.C. swivel and two-bolt swivel flange ends. Write for IEB-50 for complete information.

Aeroquip

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INDUSTRIAL DIVISION, VAN WERT, OHIO
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AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

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TEFLON is Du Pont's trade name for its Tetrafluoroethylene resin.

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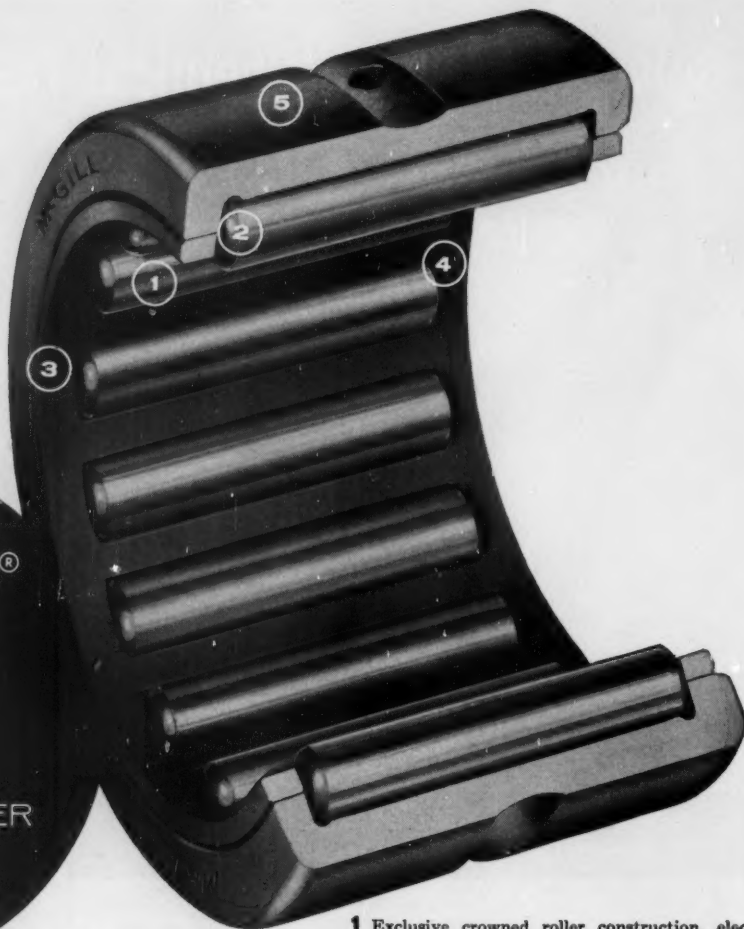
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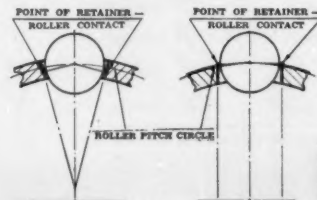
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- 1** Exclusive crowned roller construction, electronically gauged to insure precision contour and size uniformity. Relieved ends assure even load distribution.
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- 4** Simultaneously punched pockets assure accuracy of race and roller alignment. The black ferrous oxide retainer finish absorbs and retains lubrication, reducing the friction coefficient.
- 5** SAE 52100 steel outer race has optimum hardness and surface finish.



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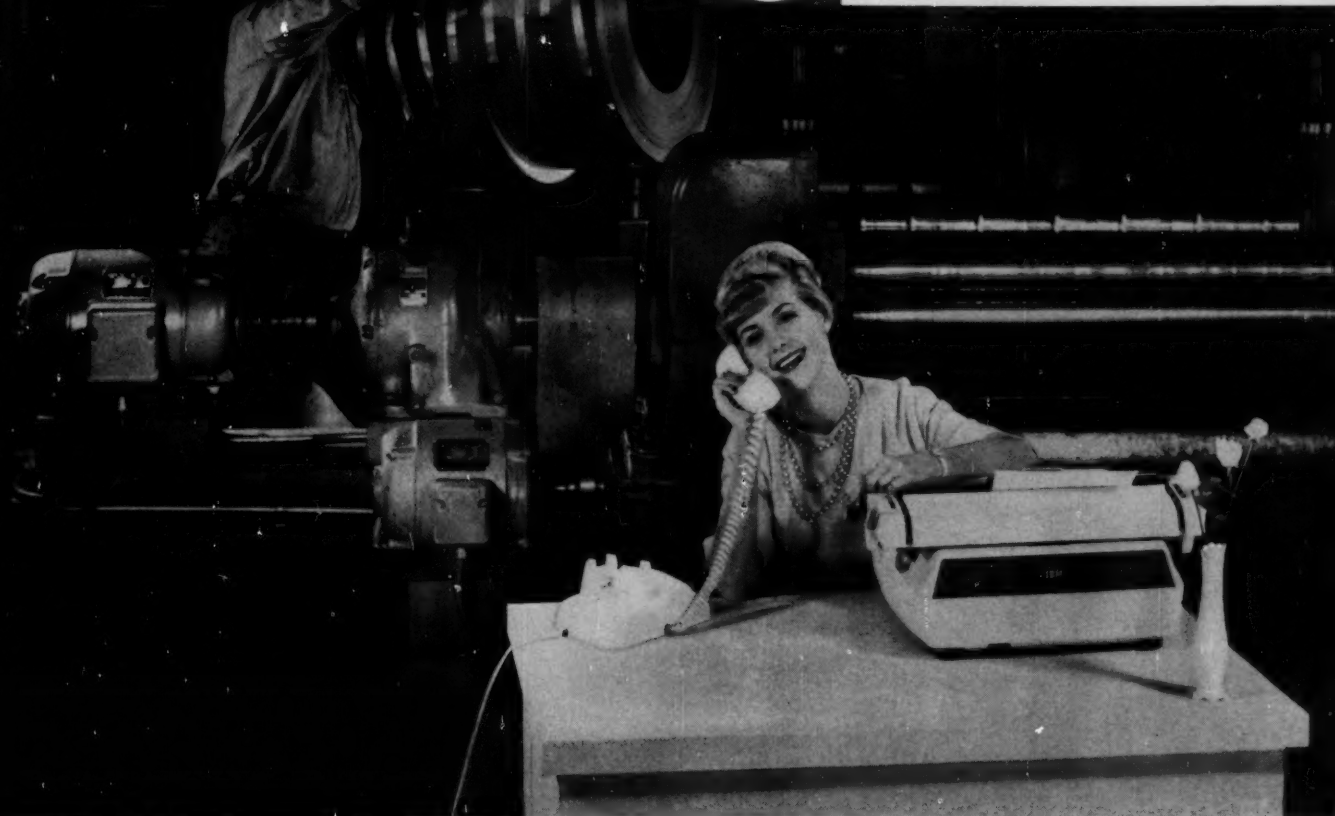
precision needle roller bearings





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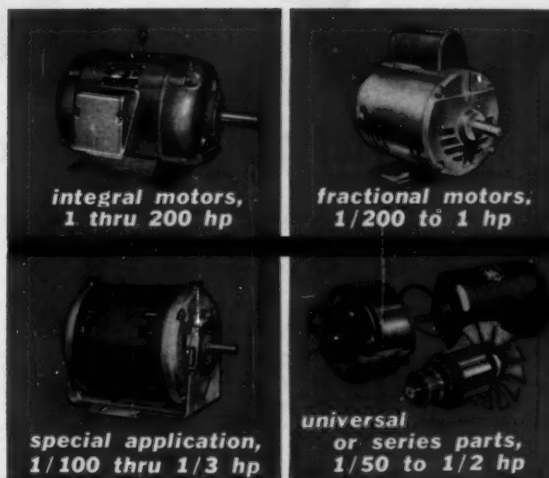


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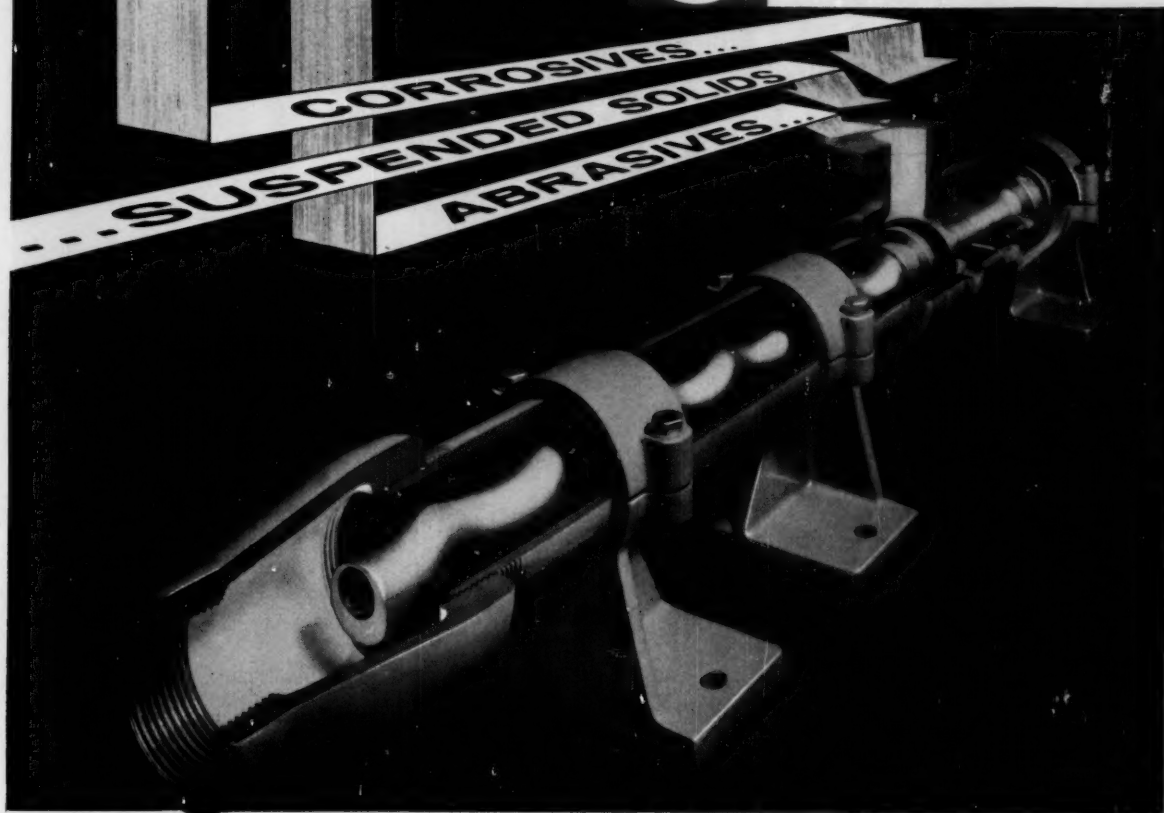
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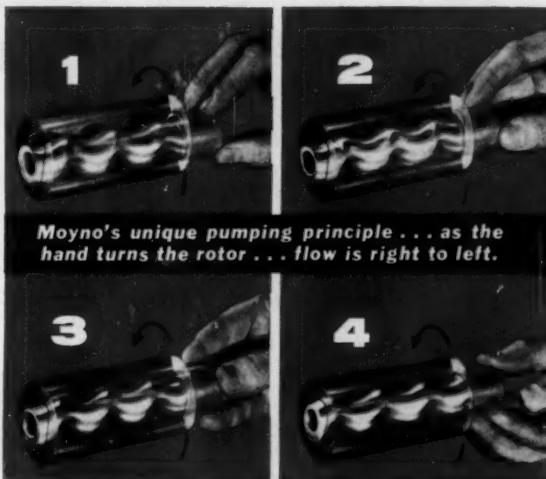
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Moyno pumps are available in capacities to 500 gpm; pressures to 1000 psi. Learn more . . . write today for new Bulletin 100-MD!

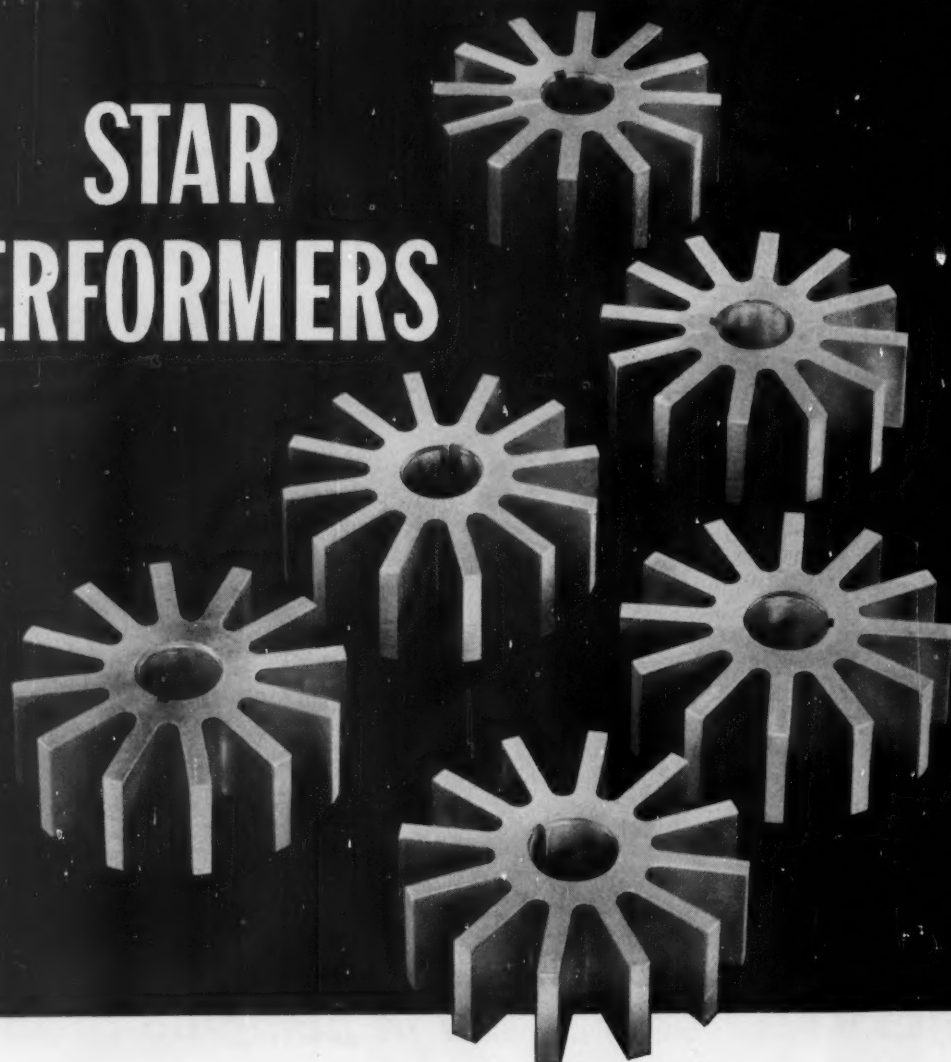


Moyno's unique pumping principle . . . as the hand turns the rotor . . . flow is right to left.

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Impellers for a ventilator pump must be held to extremely close tolerances.

Madison-Kipp showed the way to produce these parts with a bare minimum of secondary operations.

If it is an intricate shape, a question of close tolerance, a problem of casting-in inserts or just a dependable source for quality castings in quantity, the engi-

neering skill, die making experience and years of manufacturing background of Madison-Kipp are available to you.

We have a 24-page book showing some of the die casting problems we have solved, and containing information on other Madison-Kipp products. A copy is yours for the asking.



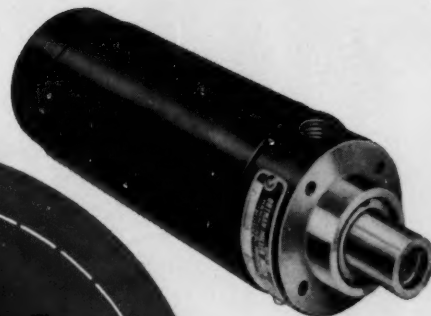
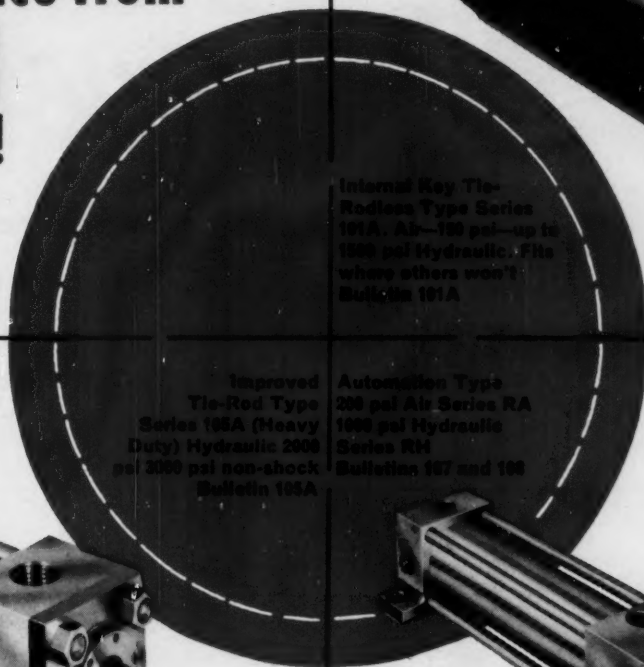
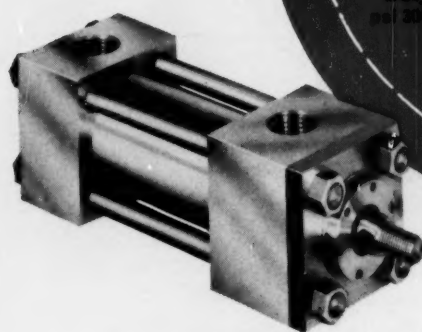
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Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High-Speed Air Tools

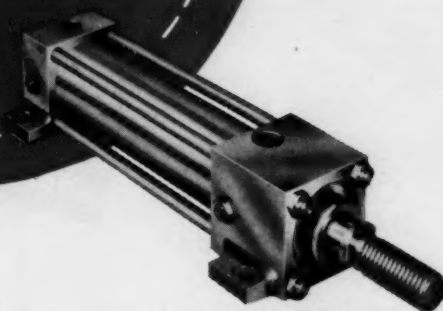
Precision Parts Assure Precision Performance from **O-M** Cylinders!



Internal Key Tie-Rodless Type Series 101A. 40-100 psi—up to 1000 psi Hydraulic. The where others won't Bulletin 101A

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With all matching parts and mounts machined to close tolerances, O-M Air and Hydraulic Cylinders eliminate misalignment friction, unnecessary wear on rod, bearings and packings, also reduce maintenance, when operated singly or in sequence under automatic cycling. The length and direction of piston rod travel is accurately controlled whether the job calls for moving a machine member, holding a tool, positioning, clamping, releasing a work piece, activating an indexing table or other applications. In addition, precise cushioning against piston shock on thrust and return strokes makes for smoother, dependable operation.

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If you are designing air or hydraulic cylinders into original equipment for precision control of linear motion, coupon below will bring our latest bulletins showing construction and dimensional details, engineering drawings, capacity chart and mounting data. For your copies, **MAIL COUPON TODAY.**



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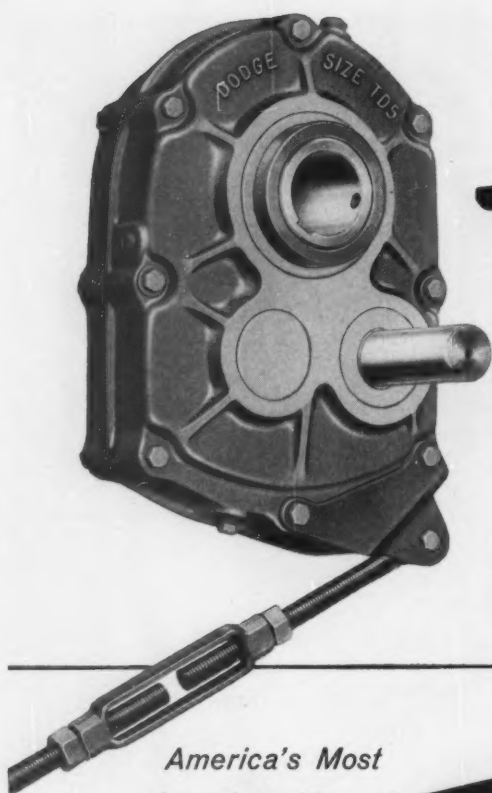
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Torque-Arm

**THE DODGE DEVELOPMENT
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In fewer than ten years, the range of Torque-Arm Shaft Mounted Speed Reducers has increased from 6 to 55 models, to meet the ever increasing demand for this improved method of speed reduction.

By eliminating foundation, sliding base and flexible coupling this modern speed reducer has saved untold installation time and untold dollars of cost.

The rugged semisteel housing developed by Dodge has never been improved upon. It is corrosion resistant—and it has the strength to hold bearing seats in line for the life of the unit.

Dodge design provides wide spacing for the bearings. Loads are carried easily, contributing to Torque-Arm's long life and very high efficiency. The gears are finest quality—helical, heat treated steel.

Torque-Arm mounts vertically or horizontally in any position around the driven shaft. It locks to the shaft on *both* sides of the housing. The holes in the output hub provide simple removal with puller. Overload release and built-in backstop are optional.

Dodge Torque-Arm is America's most widely used shaft mounted speed reducer. It is stocked by your local Dodge Distributor. Ask him. Or write us for bulletin.

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Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an extra 10% price savings on our big "stock" selection of:

Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
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Strokes up to 36", cushioned and non-cushioned.

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Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shel" Tubing End Seals, and other exclusive standard features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to exceed J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

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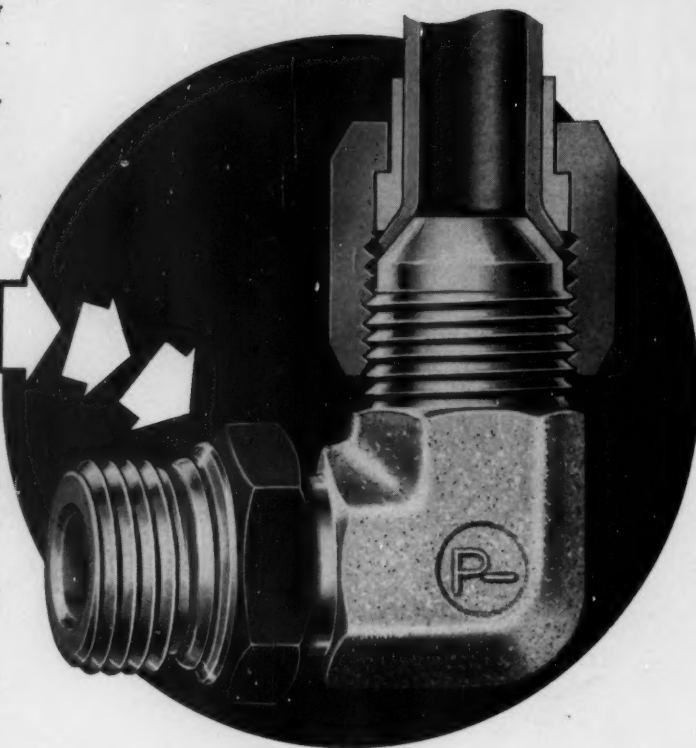
ALL ARE WORKING STOCKS - DELIVERABLE
COUNTERBALANCE CYLINDERS - BOOSTERS

Circle 464 on Page 19



PARKER PIONEERS AGAIN LEAKPROOF PORTS WHATEVER THE FLUID !

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NEW



PARKER NOW OFFERS A METAL SEAL TO FIT THE S. A. E. STRAIGHT THREAD BOSS

Parker, whose straight thread fittings and straight thread ports have been accepted by S.A.E. (and now by J.I.C.) as industry standards for hydraulic devices, has now developed a stainless steel seal for use where the conventional, synthetic rubber "O" ring is not acceptable.

Their new all-metal straight thread fitting features this resilient stainless seal, which seats within the confines of the S.A.E. straight thread boss configuration. The new seal cannot be removed from the fitting and, therefore, cannot be lost. It can be used again and again without damage to the boss or to itself. Because it is 303 stain-

less, it works equally well with every known hydraulic fluid, petroleum-base or fire-resistant.

Parker offers steel and stainless steel straight-thread fittings with stainless seals in both their "Triple-lok®" 37° flare design (illustrated) and their "Ferulok®" flareless, "bite-type" design. Also available from Parker are tools with which to cut the mating S.A.E. boss.

Hydraulic designers who have hesitated to standardize on the leakproof S.A.E. straight thread boss on applications where they could not be sure what hydraulic fluid would be used are invited to write for complete engineering test data on this new development.

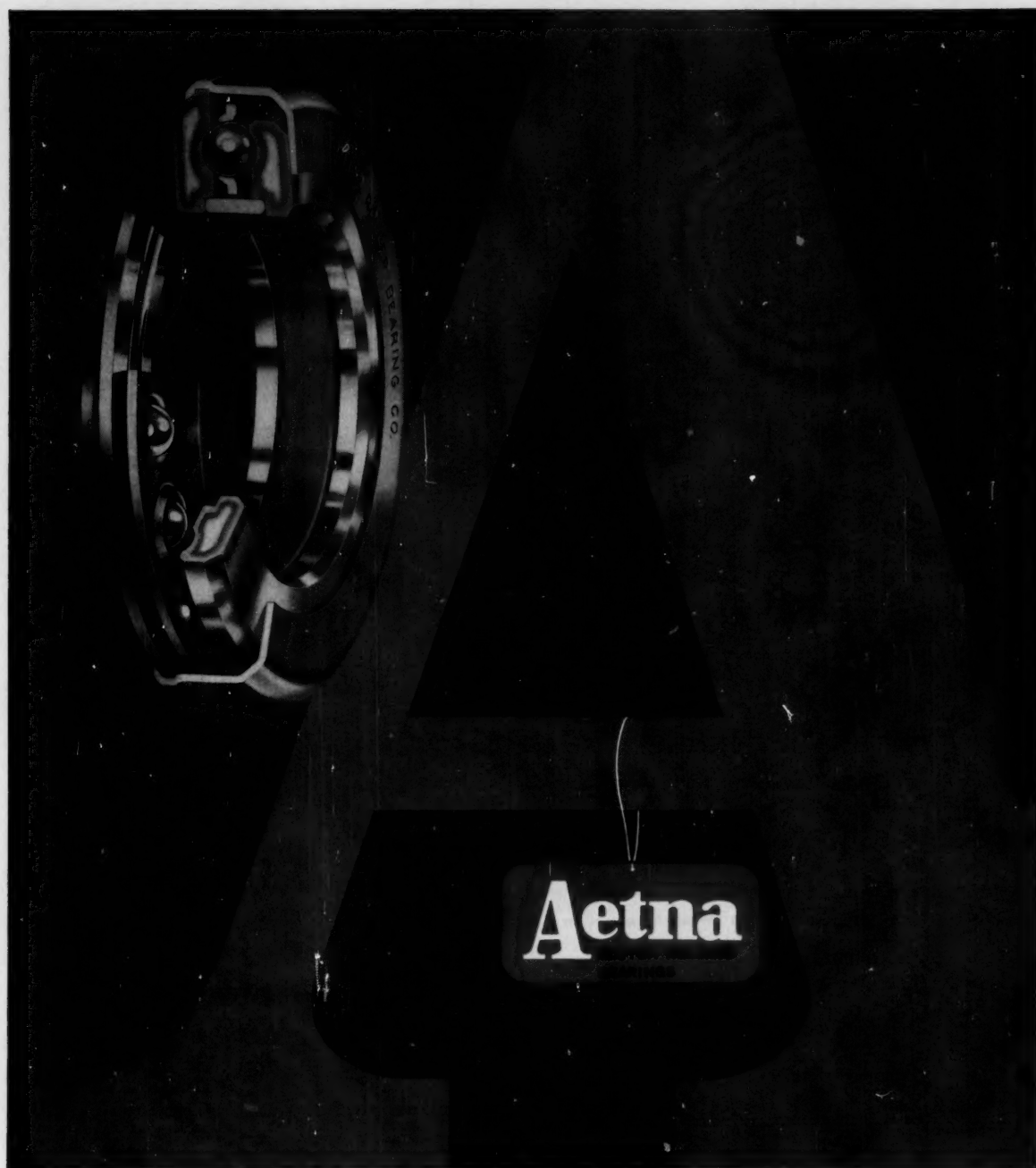


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LISTEN . . . THEY'RE SO QUIET Put an Aetna bearing to the noise test and listen. Aetna bearings are quiet. They run smoothly and silently on and on without a trace of crackling or whine. This is because Aetna bearings are sound tested under prescribed load to uncover all traces of dirt, chatter, groove wobble, tight cage, and other imperfections. Sound testing is an important part of our quality control. And it assures you of consistently dependable bearing performance for your applications. For information on the complete line of Aetna ball and roller bearings, call your Aetna representative listed in your classified directory or write for General Catalog and Engineering Manual.

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**Most versatile
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**ONLY ROTO-MISSION GIVES YOU
ALL THESE FEATURES**

- Concentric configuration
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- Requires neither driving pulley nor coupling
- Casehardened helical gears—ground after hardening for perfect engagement
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- Progressive overload capacity to the extent that no breakage of gears can result even from the severest abuse
- *Ability to engage or disengage driving action—mechanically, pneumatically, hydraulically or electrically
- *Ability to provide load releasing, load limiting or overload alarm
- *Ability to provide 2-speed operation

*Standardized accessories to provide these features are available for all sizes of Roto-Mission from stock. This results in a single responsibility for installation performance.

This new rotary transmission design combines a wide range of reduction ratios, high torque capacities, and excellent space-saving characteristics to give you more application versatility than ever before possible. It is designed to be concentrically mounted on a machine drive shaft in place of the drive pulley and operate this shaft at a reduced speed from that of the driving motor. For maximum compactness and convenience, all its parts are inside the casing.

The standard accessories available for each model of Roto-Mission add even greater versatility. Through them you have systems—from a single source—capable of control functions that previously required a number of unmatched units from several suppliers.

Because of its versatility and sound engineering, Roto-Mission permits you to solve design problems far beyond the range of other transmissions—may even permit incorporation of features in your machines that have not previously been possible. For complete information on this new product—how it operates and how it can help you—write today for Catalog IR-60.



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Metallurgical Phenomena... and the metals to cope with them.

These are the stock-in-trade of the Lukens Application Engineer—whether the problem be one of abrasive impact (symbolized above) or corrosion or pressure or structural stress or high and low temperature. Investigation of the best steels for “problem” applications has been carried on for years by the Lukens Application Research team. We would welcome the opportunity to contribute the results of this research to your own design knowledge. Please contact us in your early design stages. Call collect: Joe Proctor, Manager of Application Engineering, Extension 422, Lukens Steel Company, Coatesville, Pennsylvania.



HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB





Smallest of the Small. A pigmy beetle could easily crawl through the eye of an ordinary sewing needle, as shown by this equally magnified view of both. Among the tiniest of insects, some species of pigmy beetles reach about one-hundredth of an inch in length.

Miniature for Missiles. This tape recorder, shown one-sixth actual size, is a vital unit in the communications system of the Army's "talking satellite." Constant low-torque and quiet operation of MPB bearings in it maintain accurate tape position.

Man with Miracles. Like all MPB Sales Engineers, Pete Weinert helps solve miniaturization problems — by acquainting people with MPB service and facilities for engineering, research and experimental work. He's ready to do the same for you.

Miracles in Instrumentation

ACTUAL SIZE OF THE MPB BEARINGS
IN TAPE RECORDER SHOWN ABOVE



Little Things That Count. There's nothing new, in the larger sense, about ball bearings. But miniaturization of these familiar components is a wholly modern development. Forty years ago, for example, MPB was first to manufacture bearings with O.D.'s as small as $\frac{3}{8}$ ", and with precision that brought new aid to science and industry. Today, after continual pioneering in miniaturization, MPB produces over 500 types and sizes of bearings, ranging down to $\frac{1}{10}$ " O.D., with specials as required. Our catalog brings you details on these bearings. Write for it, or for engineering advice, to **Miniature Precision Bearings, Inc.**, 71 Precision Park, Keene, N.H.

MPB *Helps you perform
miracles in instrumentation*

HOKE Flow Sheet ²

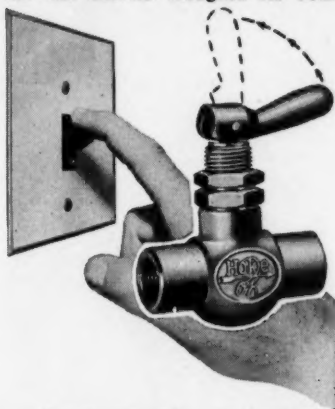
HOKE REPORTS ON FLUID CONTROL

WE'VE PACKED PERFORMANCE IN A PACKLESS VALVE

How to be "Flip" About On-Off Control

We've turned the tables on electrical engineering pros who try to demonstrate current flow by describing a valve on a pipe. Our switch-action toggle valves stop and start flow just as easy as: Flip, it's on! — Flip, it's off!

These valves perform a basically simple function, but a lot of engineering went into them to insure perfect performance. Many are used on precision test equipment and for control applications, often in conjunction with automatic controls as a manual safeguard for fast shut-off. Designed for both



gas and liquid service, the stem seals are tight enough for most vacuum work, too. We certainly can't be flip about these specifications.

Hoke manufactures two types of toggle valves. The 450 Series has maximum operating pressures up to 200 psi. These are spring closing valves made in 1/4" and 1/2" pipe sizes which can be classified as "miniatures", measuring less than 2" in height in the closed position. They are normally supplied with moulded, black, Nylon handles, but colored handles can be supplied for special identification purposes. Panel mounting lock-nuts are included as standard equipment on every valve.

The second type is the 490 Series, a cam-closing toggle valve for service up to 2000 psi. They'll give you the same quick, positive action as the 450 Series, while performing the toughest laboratory and process jobs. The 490 and the 450 are excellent performers on non-critical high vacuum. They can be helium leak-tested for this purpose.

So, if you're interested in switch-action flow control, investigate the Hoke toggle valves. We'll be happy to equip you with complete technical data. A check in the coupon to the right will bring you the facts.

The development of packless valves has so greatly reduced the problems of handling high pressures, temperatures and vacuums, and dangerous fluids that engineers designing such systems can now spend more time curled up with the Hoke Corrosion Chart.*

With this extra time, many have dreamed up weird applications for the Hoke 440 Series bellows seal valve, trying to snare us in our own semantics. In a rash moment, we boasted that this valve could be modified for almost any application. Actually, the 440 can be modified to work at high pressures (up to 2000 psi), for high temperatures (up to 1000°F.), and for special connections such as tubing, socket welding, and silver brazing.

Aside from this horn-blowing, here are the dry facts. The basic design includes a stainless steel body, inert arc-welded bellows assembly, Teflon gaskets and Teflon stem point discs. This is only the starting point. Minor modifications make so many models available that almost any problem, including liquid metal handling, can be solved.

Hear what a disbeliever said: "I did not believe that the modified valves would satisfy all my requirements, especially to keep a high vacuum of the order of 10⁻⁶ mmHg under a wide variation of temperatures; however, I now acknowledge that the modified Hoke 440 valves fulfilled their duty perfectly." This came from The Martin Company, where we sent 440's for use in cesium vapor up to 400°F. Special



The cesium boiler shown above uses a modified version of the Hoke 440 series bellows seal valve (at right) to handle high vacuum of 10⁻⁶ mmHg and cesium vapor at temperatures up to 400° F.

modifications made these valves readily usable on a cesium boiler and converted an infidel to the true valve.

If you work with critical high vacuum, high pressures, high temperatures and dangerous fluids, proceed with care. Ask for our Packless Valve Bulletin to reap a harvest of engineering plums.

* Makes good reading if you're handling corrosive agents. Write, and we'll send you one.

FREE! A STEADY FLOW OF FACTS!



Further flow features, and interesting technical topics are carefully covered in Hoke's technical publication, the FLOW SHEET. It's free, but worth millions! To get the full benefit of our engineering and editorial efforts six times a year, mark your "X" in the proper box.

Hoke's Performance Guarantee — Every Valve Leak-Tested!

HOKE INCORPORATED

91 Piermont Road, Cresskill, N. J.

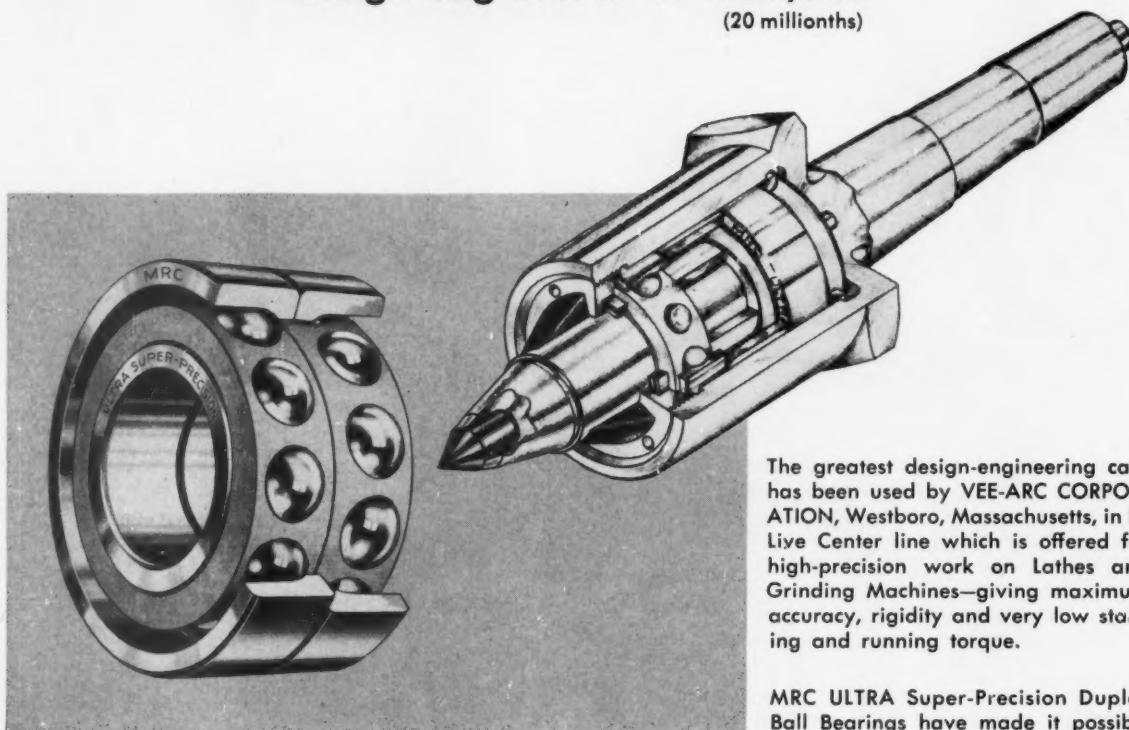
Send me complete information on the Hoke products checked below:

- ☐ Packless Valves
- ☐ Toggle Valves
- ☐ Flow Sheet
- ☐ FREE Corrosion Slide Rule
- ☐ Complete Catalog GE 959

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COMPANY _____
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CITY _____ STATE _____

MARLIN-ROCKWELL
RELIABILITY
COUNTS

IN **VEE-ARC** SUPER-PRECISION Live Centers..
 design-engineered to .000,020"
 (20 millionths)



MRC pioneered, developed and produces ULTRA Super-Precision Ball Bearings to provide the ultimate in accuracy.

The greatest design-engineering care has been used by VEE-ARC CORPORATION, Westboro, Massachusetts, in its Live Center line which is offered for high-precision work on Lathes and Grinding Machines—giving maximum accuracy, rigidity and very low starting and running torque.

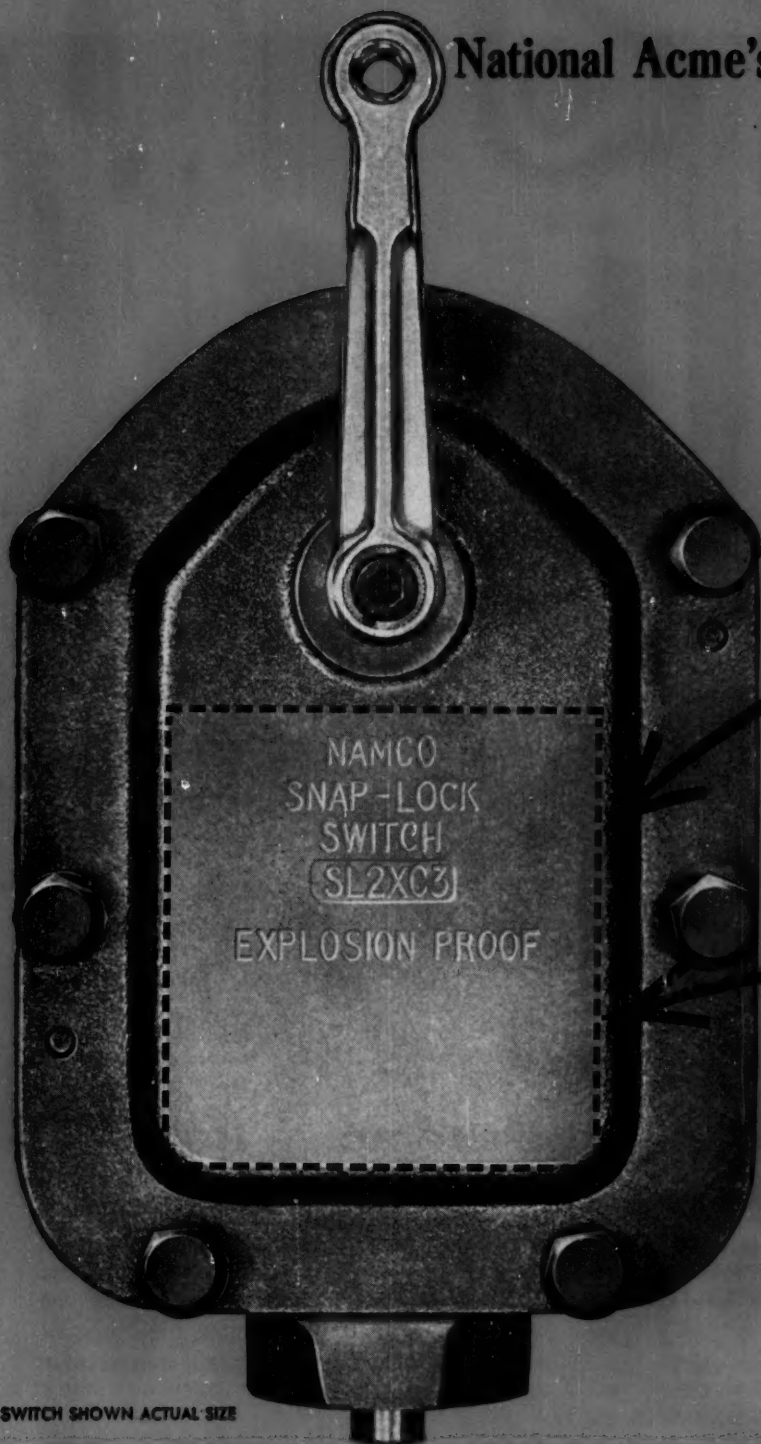
MRC ULTRA Super-Precision Duplex Ball Bearings have made it possible for VEE-ARC to guarantee a total run-out, accuracy of 20 millionths of an inch, combined with low starting and running torque.

Consult OUR Engineering Department on YOUR Bearing Problems

MARLIN-ROCKWELL CORPORATION

Executive Offices: Jamestown, N. Y.

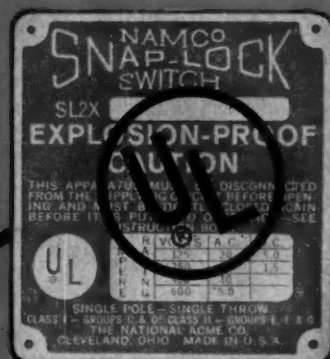




SWITCH SHOWN ACTUAL SIZE

National Acme's SL2X limit switch

doubly certified
explosion
proof



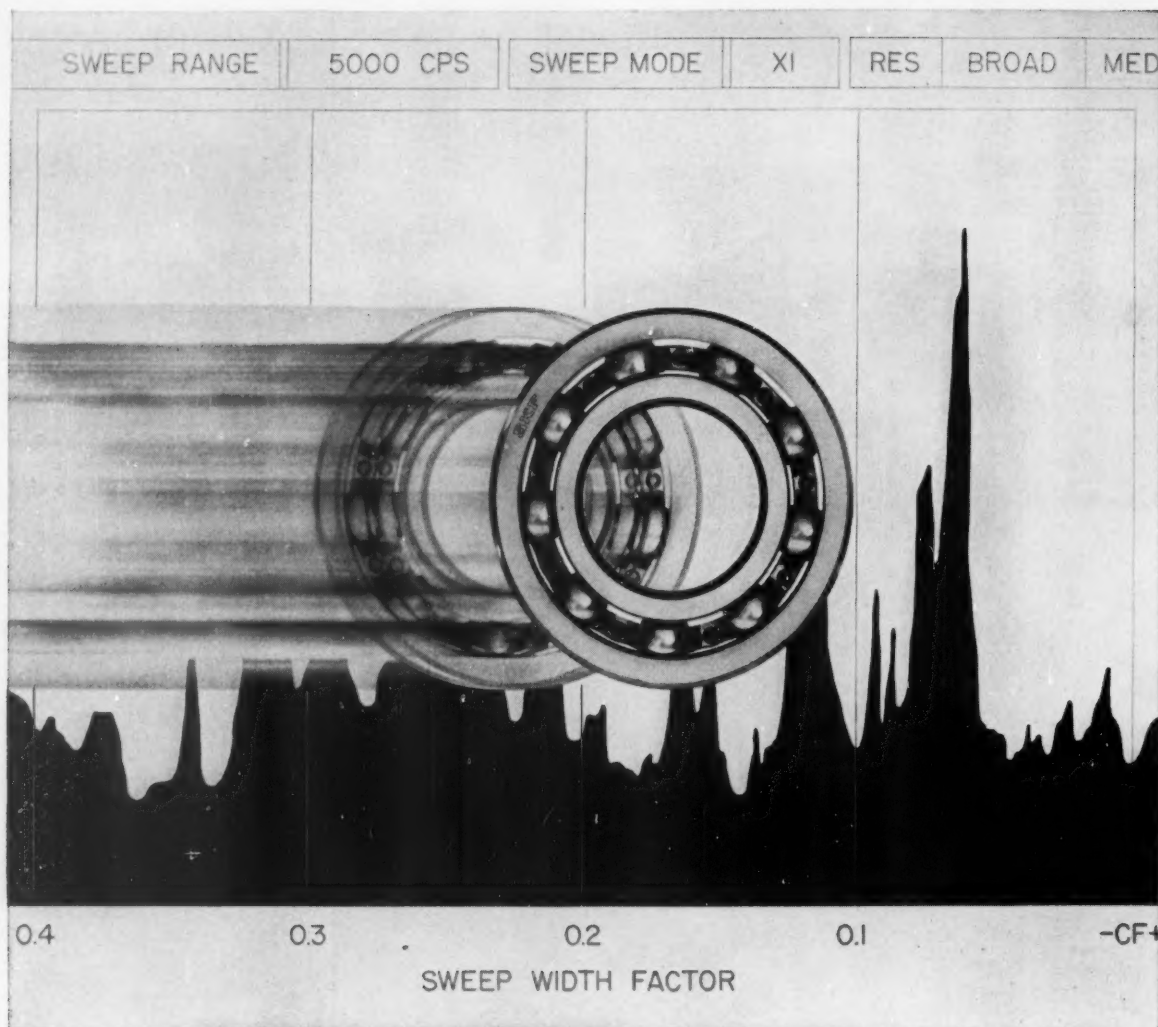
Specify National Acme's SL2X . . . and eliminate limit switching problems under explosive conditions. Tested and certified "explosion-proof" by both Underwriters' Laboratories and the Bureau of Mines, the SL2X is specifically designed for use in the mining, chemical, process industries . . . anywhere explosions cannot be tolerated. Latest of National Acme's dependable SL2 "Machine Life" Limit Switches, the SL2X also offers . . . a variety of cam arrangements for extreme operating flexibility . . . ample overtravel (67°) and by-pass (90°) . . . light operating pressure (12½ lbs. at 1½" radius). Get all the details on this new standard of limit switching dependability and safety. Call, write or wire.

**National
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THE NATIONAL
ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N.J., Chicago 6, Ill., Detroit 27, Mich.

Circle 472 on Page 19



Now, **SKF** reduces the noise level of ball bearings by 50%!

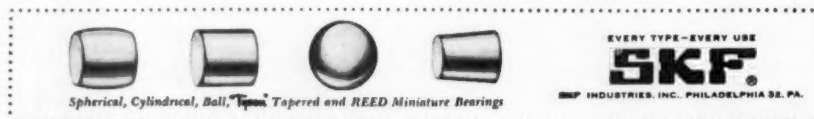
New **SKF** ball bearings run twice as quietly as standard single-row deep-groove bearings — six times more quietly than bearings produced just two years ago.

They're designed especially for applications where noise is an important factor. Eight manufacturers, who use-tested them for over a year, now back-up their approvals with repeat orders.

Every bearing meets new, more critical standards. Each type and size meets special requirements for reduced vibration. Every ball meets very low waviness limits. Each cage meets critical standards for smooth, quiet performance.

SKF will make a comparison check of these improved bearings against the bearings you're now using. See for yourself! Just call the **SKF** branch office nearest you.

6013



The country's leading valve manufacturers select **Flexonics** bellows for reliability and long life

To isolate contaminants, resist corrosion, assure reliable sealing and minimize servicing—leading valve manufacturers are adopting bellows for packless valve stem seals. Experience has proved the reliability and longevity of a bellows for performing this function, and Flexonics is the leading and most experienced supplier of bellows to this industry.

However, valve seals are but one illustration of the

growing applications of bellows where high pressures, high temperatures, severe corrosive conditions and other complex problems are involved. Perhaps a bellows can be the answer to your design problem. The Flexonics Application Engineering Staff will be pleased to study your specific problem and make recommendations. Or, if you prefer, write for the Flexonics Bellows Design Guide... 20 pages of valuable information.

9-533



Flexonics

corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.



EXPANSION
JOINTS



METAL
HOSE



SYNTHETIC
HOSE



BELLOWS



AERO/SPACE
COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

FLEXONICS CORPORATION
1339 South Third Avenue
Maywood, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.





... CONTINUOUS PROCESSING IN THE '60's ...

CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

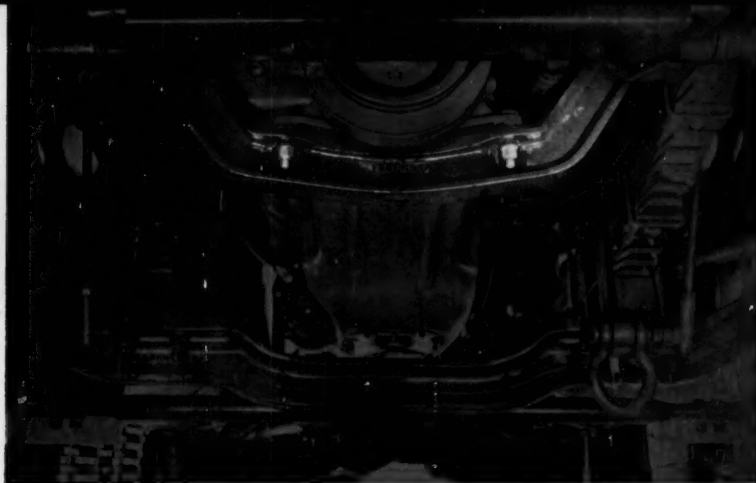
Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for **FREE 130-PAGE REFERENCE MANUAL**.



The Cambridge Wire Cloth Co.

DEPARTMENT N • CAMBRIDGE 1, MARYLAND

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications



For high strength without excessive weight, the designer of this heavy truck chose Tenzaloy for the front engine supporting frame.

Why TENZALOY is the most widely used high-strength aluminum casting alloy

Among high-strength, self-aging aluminum casting alloys, Tenzaloy has won greatest acceptance and widest use by designers because of its unique all-round combination of properties. Outstanding among these special qualities are:

- High yield and tensile strength, combined with adequate ductility
- Exceptional machinability
- Remarkable dimensional stability
- High impact, shock resistance

When Tenzaloy is specified, one big problem is eliminated: heat treatment. Without any artificial thermal treatment, Tenzaloy castings will precipitation-harden at room temperature to give properties normally obtainable only by the expensive solution treating, quenching, and artificial aging of the heat-treatable alloys.

Here are typical properties for Federated Tenzaloy:

Tensile strength	35,000 psi
Yield strength	25,000 psi
Elongation (in 2 in.)	4-5%
Brinell hardness No.	74
Impact strength (Charpy in ft.-lbs.):	
Notched	3
Un-notched	14
Electrical conductivity	35%

Tenzaloy also is corrosion resistant, has superior ductility, and is easily anodized, dyed and polished to brilliant decorative finishes. Castability is excellent in green sand, plaster, investment, shell, oil-bonded sand and precision molds of all kinds. No special techniques are required for handling Tenzaloy in the foundry. Since Tenzaloy has mechanical properties equivalent to such common heat-treated alloys as 195T6, 355T6, 356T6 and 319T6, it can be substituted in applications where any of these heat-treated alloys are presently used.

It is particularly suited to high-strength designs where load carrying capacity and impact strength are essential. For example: frames, brackets, levers, bases, housings, missile ground handling equipment, jet aircraft turntables, explosion-proof enclosures, heavy-duty wheel hubs and cable drums, to name a representative few.

Tenzaloy can widen your design possibilities, increase production efficiency, improve your products, reduce costs. Get complete facts on its physical and mechanical properties by writing for Bulletin No. 103 R5 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

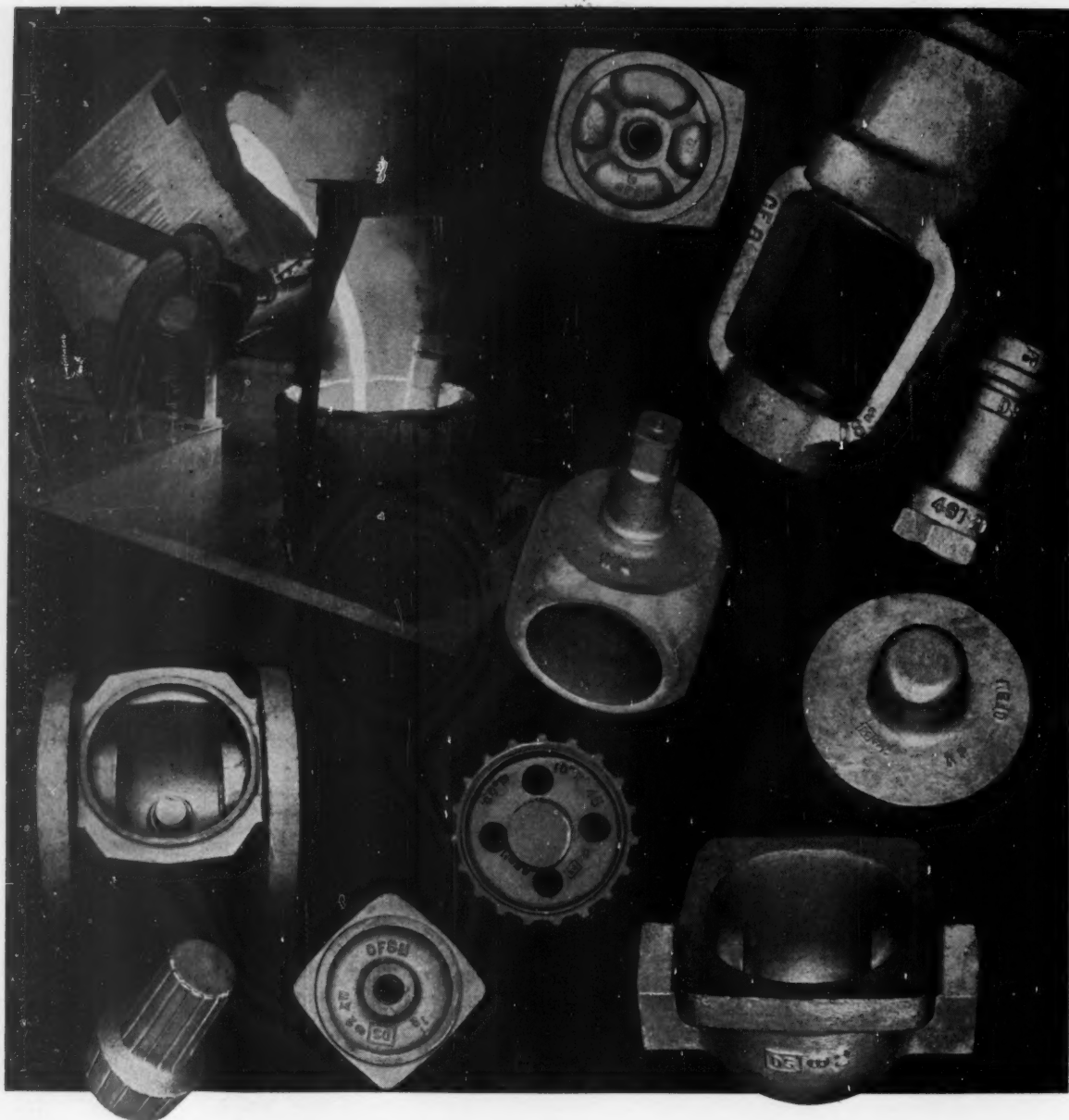
FEDERATED METALS DIVISION

TENZALOY

ASARCO

American Smelting and Refining Company
120 Broadway, New York 5, N. Y.

Circle 476 on Page 19



NAME YOUR **STAINLESS** SHAPE!

The design and manufacture of quality stainless steel castings is a specialized job . . . and *Dodge specializes in it!*

There is practically no limit to the variety of shapes we can turn out to meet your simple or intricate specifications precisely . . . economically.

Perhaps one or more **DS** castings shown here will help spark an idea of how Dodge can

be of assistance for *your* stainless steel casting needs. A blueprint or sketch with operational details will bring complete information, without obligation.

DODGE STEEL COMPANY

6501 State Road

Philadelphia 35, Pa.

• Phone: DEvonshire 2-2200

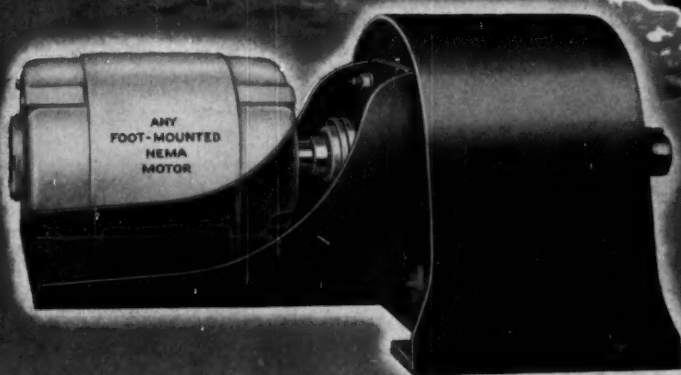
DS

**DODGE
PRODUCTS**

THE MOST IMPORTANT ALLOY IN A **STAINLESS** STEEL CASTING IS QUALITY

FALK

A GOOD NAME IN INDUSTRY



**20,000 hp
at 100 rpm**

**...or 75 hp
at 100 rpm**

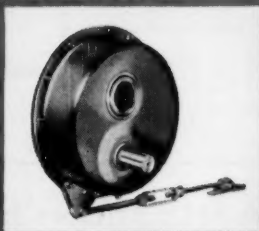
THE FALK ALL-STEEL, ALL-MOTOR MOTOR REDUCER
(also available in integral models)

**...one of America's First Family
of Power Transmission Products**

Other Members:

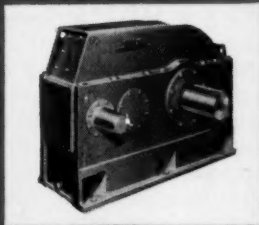
**SHAFT MOUNTED
DRIVES**

—up to 125 hp. Ask
for Bulletin 7100. Also
Flange Mounted and
Screw Conveyor Drives.



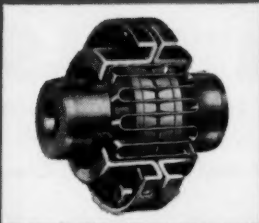
**SPEED
REDUCERS**

Parallel Shaft up to
3500 hp. Ask for
Bulletin 1100. Also
Right Angle and
Concentric Shaft
designs.



**STEELFLEX
COUPLINGS**

All-steel, torsionally
resilient. 34 sizes, from
.3 to 130,000 hp at
100 rpm. Ask for
Bulletin 4100.



FALK, ALL-MOTOR
and STEELFLEX
are registered trademarks.

If you were in the market for a 20,000 hp propulsion drive for a blue-ribbon super-tanker, you would expect and demand the ultimate in gear accuracy. On turbine-driven gears as large as 15 feet in diameter and four foot face width, any deviation in tooth-spacing tolerances of .0001" to .0002" would spell poor performance or disastrous failure...the latter entailing loss of service of the ship and ruinously expensive repairs or replacements.

Falk, producer of millions of horsepower of marine propulsion drives for nearly fifty years, has been continuously adding to its gear making experience and techniques—and applying the results to all products, standard drives as well as large special units, with the same full respect for the importance of accuracy. Today's versatile All-Steel Motorreducer is a striking example of the application of these attitudes and skills in producing the many standard gear units used throughout your own industry.

Falk gears have the highest known efficiency...98½% per mesh under full load...plus the famous Falk extra-depth, high-pressure-angle teeth. Benefits to you: better service, less maintenance, extra durability, true economy. Available in horizontal, vertical and right-angle models; sizes up to 75 hp. See your Falk Representative or Authorized Distributor—or write for Bulletin 3100.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN
MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

Representatives and Distributors in most principal cities

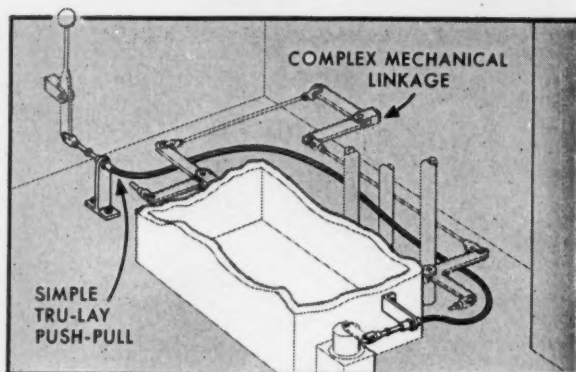
• • •

A POINT TO PONDER...when you need gear drives or shaft couplings of "FALK OR EQUAL" quality, where but from Falk can you get the "OR EQUAL"?

Circle 476 on Page 19

TRU-LAY ~~PUSH-PULL~~ CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY ~~PUSH-PULL~~ FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. ~~PUSH-PULL~~ CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike ~~PUSH-PULL~~ CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000



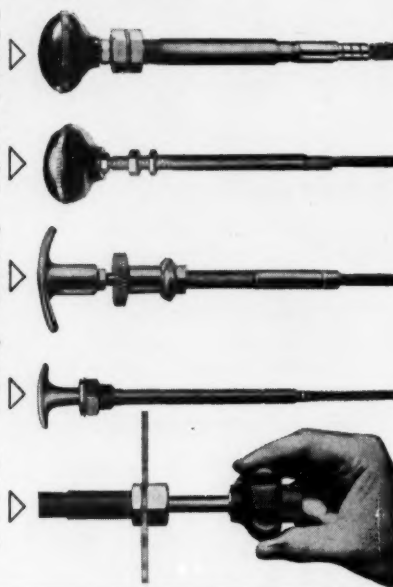
Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.



~~PUSH-PULL~~ DATA FILE shows how to simplify, improve design

~~PUSH-PULL~~ CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the ~~PUSH-PULL~~ DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of ~~PUSH-PULL~~ CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY ~~PUSH-PULL~~ CONTROLS a part of your product.


~~PUSH-PULL~~ CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.





Why the high-offset?

...and where can you use it profitably?

High-offset makes a difference!

It's the difference that lets you combine *high-reduction* with strength, compactness and other advantages you might find profitable in certain applications. For instance . . .

For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because the teeth "wrap around" the pinion, you get continuous action—even with just one or two teeth.

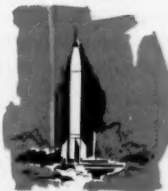


Where space is a problem—as in instrumentation—the high-offset lets you design a more compact unit.

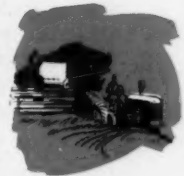
Choose just the offset to solve your design problem with a more flexible, more compact unit than the corresponding worm and wheel.

Where you need strength—as in farm machinery—high-offset hypoid pinions with teeth, which tend to "wrap around," are larger and stronger than corresponding bevel pinions.

High-offset or high-ratio hypoids can be cut on the same Gleason equip-



ment that is used on more familiar spiral bevel and hypoid gears. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish. For ratios of 1:10 or 1:40 or even higher.



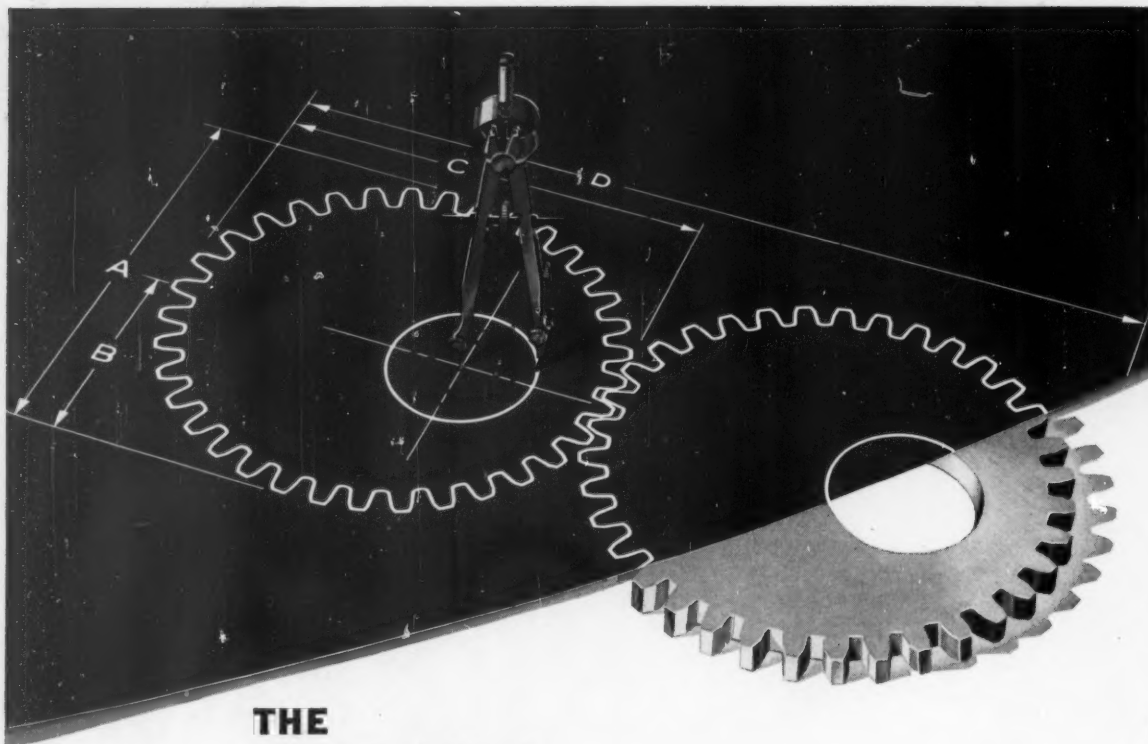
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GLEASON WORKS

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Circle 480 on Page 19



THE FELLOWS GEAR SHAPER

... adds a new dimension to your design techniques

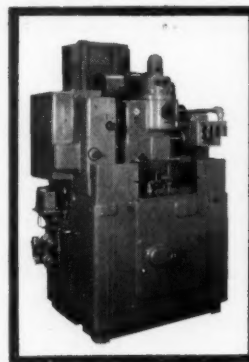
Designs that are right from a functional standpoint, often appear to be impractical from the standpoint of economical production.

To avoid compromising the functional design of non-circular gears or non-involute parts, many companies rely on the unique production capabilities of the Fellows Gear Shaper.

Parts that look complicated (and are complicated to design) become routine jobs in production on the Gear Shaper. Depending on design, some parts are best produced on single purpose machines. Many others can be produced on standard machines using special fixtures and standard, or special, Fellows cutters.

And, of course, the standard machines will generate internal and external spur and helical gears in a range from "miniatures" up to 120" P. D.

"The Art of Generating with a Reciprocating Tool", a fact-packed 48-page catalog, gives details on the versatile Fellows method. May we send you a free copy?



4GS Gear Shaper

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont, U. S. A.
Branch Offices:

1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

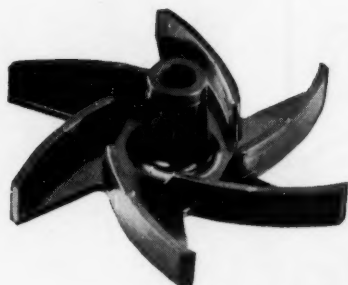
THE
PRECISION
LINE

Fellows

Gear Production Equipment

PRODUCT-DESIGN BRIEFS FROM DUREZ

- Phenolic for pumps
- Dip-coating compounds
- Plastic process equipment



FLINT & WALLING MFG. CO., INC.

Why not?

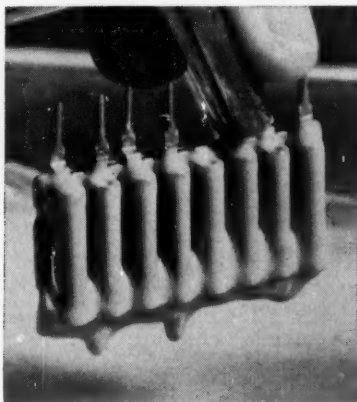
Here's a good way to engineer more profit into a pump.

The impeller is phenolic. It won't rust or corrode; it defies stubbornly the onslaughts of acid, oil, alkali, and soap.

A cubic inch of molded phenolic costs much less than you'd allow for a more traditional impeller material. Forget about machining; phenolic parts seldom need any.

If a pump must handle liquids as hot as 300°F, don't let that stop you from specifying phenolic.

We can work with your molders on the application you have in mind. Why not write us about it? Or simply check the coupon for Bulletin D400. It lists the properties of a typical Durez phenolic molding compound used in pumps, and includes much other useful information.



Coat for components

Looking for a simple encapsulating idea? Here's one that works well at heatproofing, moisture-proofing, and preventing shorts in small electrical components. It's non-messy, too.

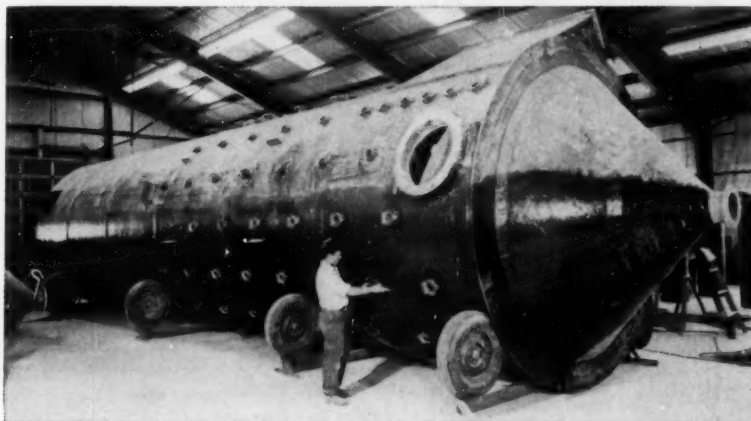
Dunked in a paste coating, dried, then baked for a short time, components steadfastly resist extremes of heat and moisture that would otherwise raise havoc

with their electrical reliability.

Components so coated can be soldered into a circuit without causing the coating to melt or peel. It won't soften, and easily passes a series of -55 to +85°C cycles. One thousand hours at a sweltering 150°C will turn the coating almost black but still won't materially affect the component inside.

The paste is made with Durez phenolic resin-and-filler compounds supplied in powder form. There's a choice of densities and toughnesses. One type is impervious to ketone solvent cements sometimes used in assembling radio and TV chassis.

What can these dip-coating compounds do for you? We'd like to help you find out. Write for more detailed information.



FABRICATOR: DU VERRE, INC., ARCADE, N.Y.

What's your big idea?

Think big. A 50-foot plastic boat... a 150-foot plastic radome... or a plastic chemical scrubber like this behemoth designed and sold by Buffalo Forge Co.—all are actualities today, with an assist from glass-reinforced Hetron® polyester resin.

The scrubber is expected to save someone a lot of money. In corrosive situations, Hetron has repeatedly proved it can outlast other commonly used materials by a factor of two, three, or more. First cost can be as low as one-third that of other special corrosion-resistant materials.

There's one other important point: safety. Hetron is inherently self-extinguishing. It retards fire because of its unique molecular configuration. Often, a Hetron installation—whether it's ducts, fume hoods, tanks, stacks, or blowers—can obviate the need for a sprinkler system.

If you'd like to know what the process-equipment fabricators are doing nowadays with this versatile, safe polyester, use the coupon. We'll gladly send you a data file on Hetron, including a list of leading fabricators who can shape it to your specifications.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400)
- ☐ "Phenolic Resin Compounds for Dip-Coating"
- ☐ Hetron polyester resin (data file and list of fabricators)
- ☐ "Durez Plastics News" (a review of current plastic applications, mailed bimonthly)

Check, clip and mail to us with your name, title, company address.
(When requesting samples, please use business letterhead)

DUREZ PLASTICS DIVISION

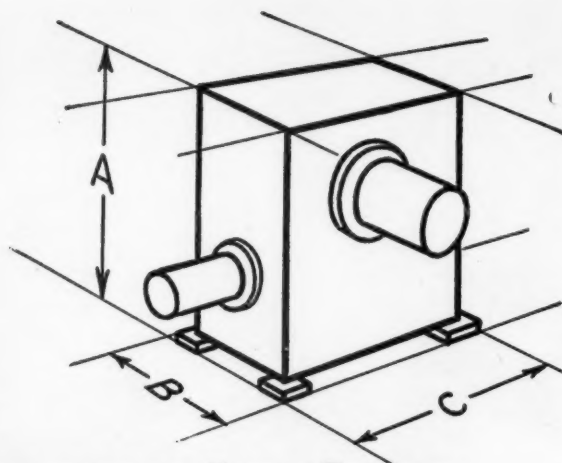
501 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION



Do-It-Yourself...

Let's design a speed reducer today



So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You

can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

KEYSTONE WIRE for vital parts of Bissell Sweepers

Bissell Inc., world's largest manufacturer of carpet sweepers, with a global reputation for quality, specifies Keystone Wire for the vital parts of their Bissell Carpet Sweepers.

In this popular model, the axle rods are made of Keystone Silver Brite Galvanized Wire; the sturdy brush bristles are anchored in a solid wood roller with staples made from Liquor Finish Stapling Wire. Keystone high carbon Spring Wire is specified to absorb the flexing action of the wheels.

Walter Bradcoski, Senior Buyer, says, "Keystone Wire has always met our requirements exactly and is used in all our sweepers."

Keystone Wire Specialists have developed wire with correct thermal treatment, chemical analysis, surface and uniformity for Bissell Sweepers. These metallurgical engineers who know wire thoroughly, are always ready to offer you their experience to help you modernize your wire needs. They will recommend the wires best suited for your requirements. Call them soon...it could be a profitable contact!

Keystone Steel & Wire Company, Peoria, Illinois



Sweeper rotary brush is made with
Keystone Brush Twisting Quality Wire.



KEYSTONE WIRE FOR INDUSTRY

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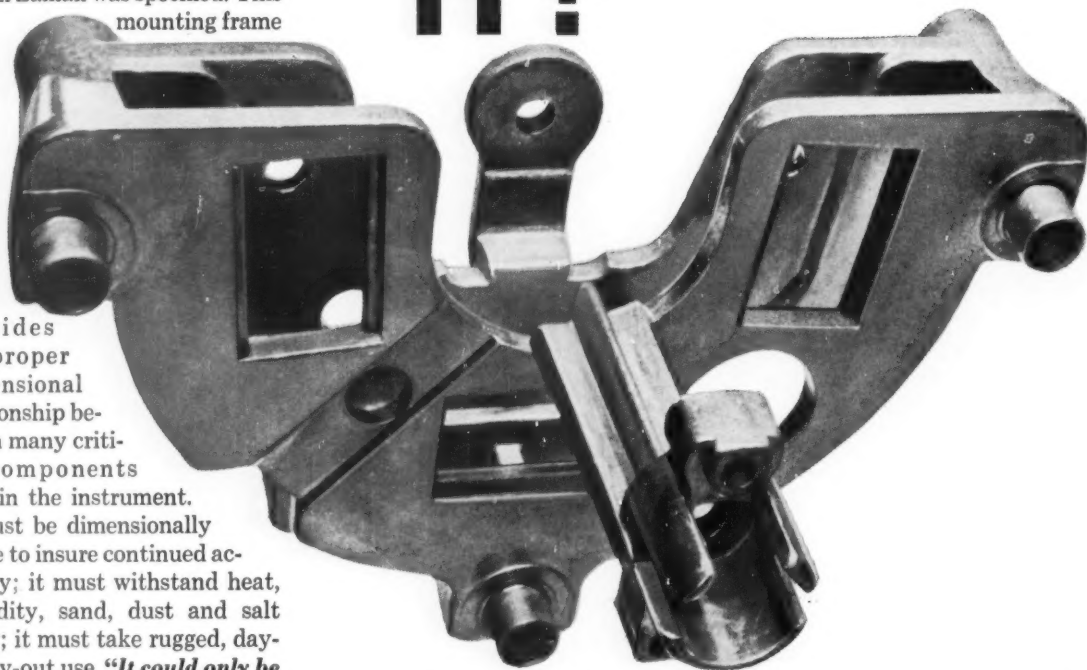
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January 19, 1961



Back to Newton

ENGINEERS, too often, seem uninterested in the gentle art of persuasion. Letting the facts speak for themselves should, we tend to feel, accomplish a desired result.

But does it? If that were all that's necessary, where do you think Mr. Kennedy would be today?

Engineering, to the chagrin of its practitioners, has never enjoyed the status of the other learned professions. Yet the favorable impact of engineering on people's daily lives is certainly as powerful as that of the others.

The legal profession, however, has acquired an impressive image of itself which facts alone could hardly have created. As professional persuaders, lawyers naturally would apply the principles of their own art to achieving recognition.

Scientists, perhaps, can get along

without much persuasive effort. But to engineers, who deal at least as much with people as with ideas and things, the art of persuasion should be as much a working tool as Newton's laws.

Come to think of it, what is persuasion but an application of Newton's first law? Isn't the "impressed force" of the classical wording but a positive effort to impress?

So it gets back to this: The engineer who scorns to develop and use his full persuasive powers is not making the broadest use of even the first principles of his own art. Del Karger's article overleaf outlines some of the "mechanics" of ethical persuasion.

Colin Carmichael
Editor



How To Sell

Good engineering projects sometimes never get beyond the stage of proposal to management. They wind up in the waste basket despite their worth. How many times is this dismal fate due to poor presentation technique?

A flashy presentation is no substitute for a worthwhile project idea. But neither should a poorly planned presentation be allowed to prevent a good idea from getting the attention it deserves.

Here are some tips on the personal and business factors that can mean the difference between acceptance and rejection.

IN THE AVERAGE company, many project proposals come to naught. Management doesn't usually leap at the chance to approve the starting of a new project, such as a major engineering investigation or the costly development of a new product.

If rejection is based upon valid business reasons, that's that. But if the idea is turned down without serious evaluation because the presentation is poorly planned, something can and should be done to improve the chances of acceptance.

Selling a proposal up through the organization involves more than meets the eye. "Selling" may be viewed by some to be a departure from the traditional engineering approach of "just presenting the facts." Preoccupation with the facts alone can be hazardous. A salesman, too, must know his product. But just as important, he must know the customer and his needs, interests, and foibles. Selling an engineering proposal requires the same kind of concern for the "customer"—the man up the line who is being asked to say "yes."

In this article, some of the kinds of factors that can help or hinder a project proposal are discussed. They do not include the obvious basics such as organization of material, effective use of the language, clear illustrations, etc.

The First Step: Any contemplated proposal should pass a preliminary test. Is it worth presenting? Right answers at this point can help prevent later rejections. After all, not all avenues of exploration

Engineering Proposals

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can be expected to prove fruitful. Poor or marginal projects should be killed before they reach the proposal stage.

But sometimes the "dogs" are hard to kill, espe-



... some dogs are hard to kill ...

cially if the proposal has been requested by higher authority. A brief, factual report that clearly shows the excess of disadvantages may be the least painful way of trying to terminate it.

The Basic Technique: Once the decision is made to present a proposal, the most important technique in selling a project to an individual is to recognize

the things that are important to him—and to plan and act accordingly. The man having a project to sell has a head start if he knows his audience—whether an individual or a group. What are the personal and business attitudes that will bear on the outcome of a proposal?

For example, the man who will be receiving a proposal may have these personal attitudes:

1. He never reads reports that have more than two pages of text.
2. He tends to look more favorably upon proposals submitted by only certain men.
3. He is tougher to work with on Mondays and Fridays.
4. He likes to digest a report by himself before it is presented generally.



... reaction of a group is unpredictable ...



... timing is important in launching a proposal ...

5. He is fearful about sticking his neck out.
6. He wants to be a V. P.

Apart from these personal factors, but equally a part of the problem, are such business attitudes as these:

1. He is particularly interested in projects that involve his technical specialty.
2. He is annoyed if the technical content of a proposed project requires new or different engineering talent.
3. He considers high profit margin to be the most important factor in a proposed new product.
4. He considers large capital investment to be a major hindrance.
5. He is strong on ease of manufacture.
6. He is reluctant to consider any new product that would require a new sales force.

Personal Factors

There is no simple outline to the job of coping with the personal attitudes of those who will be the judges of a proposal. Recognition of the need to do so is half the battle. And common sense and intuition can often carry the remaining half. Here, however, some suggestions on general techniques are offered.

Written Proposals: Many of the reports and proposals developed in industry remain partially or completely unread. Effort expended to develop them and the material they contain are all too often a total waste.

Consulting management engineers circumvent this hurdle by having an executive officer call a meeting at which the consultants read aloud the final report, inviting questions after each section. Unfortunately, most project developers are not in a position to get top management to call such a meeting. The consultant's report probably represents an expenditure of \$20,000 to \$100,000, of which management is aware. The cost, and the fact that the consultant is an outsider, make it possible for him

to force the issue. His cost is easily defined, but for an internally developed report, the cost is often buried, or is not thought of as a tangible item.

How then can the story be put across? One way is to use a newspaper writing style, telling the important things first and filling in the details at the rear of the report. This style lends itself well to emphasizing the things the reader is known to be particularly concerned about.

Above all, a report must be brief and to the point. The best way to compress a report is to rewrite it until all superfluous words have been eliminated. Ideas are important in a report. Flowery or vague language serves only to obscure the thought being presented.

Oral Proposals: Sometimes a new proposition—particularly in its formative stage—may be best presented orally. Then, the question is: Should it be presented to a group collectively or individually?

The performance or reaction of a group is much less predictable than that of an individual. This is especially true in new-project presentation. On the other hand, it is also generally true that one or two individuals usually dominate a given group and that others in the group follow their lead. Here is where an internal organization study can pay off. The presentation should be aimed at these key individuals.

If it seems better to approach the management team individually before submitting the proposal to the group as a whole, the presentations can be tailored to stress those factors of interest to the individual. This is best done through a verbal presentation with visual aids. This provides maximum flexibility and does not leave "lying around" apparently dissimilar reports on the same subject—apparently dissimilar only because of the words or order of presentation, not because of the total content or over-all meaning.

Visual Aids: There's that old but still true saying: One picture is worth a thousand words. This is a major route to short, hard-hitting proposals and reports, whether written or oral.

Visual aids include actual photographs, conven-



... if he has helped in developing the proposal ...



... how much is needed in each six-month period ...

tional graphs, bar graphs, cartoons, etc. While even ordinary quality execution helps, the more professional-looking the illustrations, the greater the impact upon the reader. Kits which help to produce professional-looking charts and graphs are available from several suppliers.

Slides, flip charts, posters, pictures, etc., can be especially helpful for oral proposals. Pass-outs during a presentation are to be discouraged because they tend to distract attention. Someone is almost sure to have questions or comments regarding the pass-outs. Also, a listener is apt to keep studying them even when the discussion has passed on to other material.

Timing: Important in launching a proposal is the right choice of time. This involves not only the time of day or the day of the week, but also the state of the business enterprise. For example, a company undergoing a managerial shakeup will hardly be receptive to radically new proposals. The best time to launch a new proposal is when business is healthy, the organization is stable, and your audience is in the mood.

Business Factors

Facts of business life include the realities of engineering, manufacturing, finance, sales, etc. Depending upon type and magnitude of the proposal, some or all of these areas become involved. And so do the attitudes of those people who are responsible for judging proposals with respect to these areas. Here is a sampling of typical problems and possible solutions.

Engineering Problems: If new technological fields are involved, and the company does not have the required talent, consider how it can be secured from professional consultants, research institutes, or university professors who act as part-time consultants. Anticipating problems of this sort and their solutions can go a long way in overcoming management resistance.

Ease of Manufacture: The best way to cope with manufacturing problems is to bring in the manufacturing specialists.

Whether called industrial, methods, or manufac-

turing engineers, these men can make a real contribution to the engineering team by helping to sell an engineering proposal, a redesign project, or a new product proposal.

One way in which industrial engineers can help is by developing supplementary exhibits for the proposal, such as labor-cost estimates, material-cost estimates, and manufacturing-process sheets which specify required tooling, equipment, etc.

The heads of industrial engineering and related functions are more likely to back up the proposal if they have helped in developing the product and in formulating the proposal.

Financial Aspect: If management is interested primarily in a high profit margin and the project involves a prospective product that has one, the task is easy—emphasize this favorable aspect. On the other hand, if the profit margin is not high, but there is a large potential sales volume at a conservative margin, call attention to total profits. Another way to present the profit story is in the manner often used by Wall Street—with emphasis on the return on the investment. Each of the two latter approaches is a legitimate and valid way to measure return.

Sometimes the product rounds out a product line and will either protect or expand the company's market position. Such side effects, in concrete dollar terms if possible, may well be telling points that deserve emphasis.

No pertinent facts should be suppressed, but those that are in line with company policy and management attitudes should be emphasized.

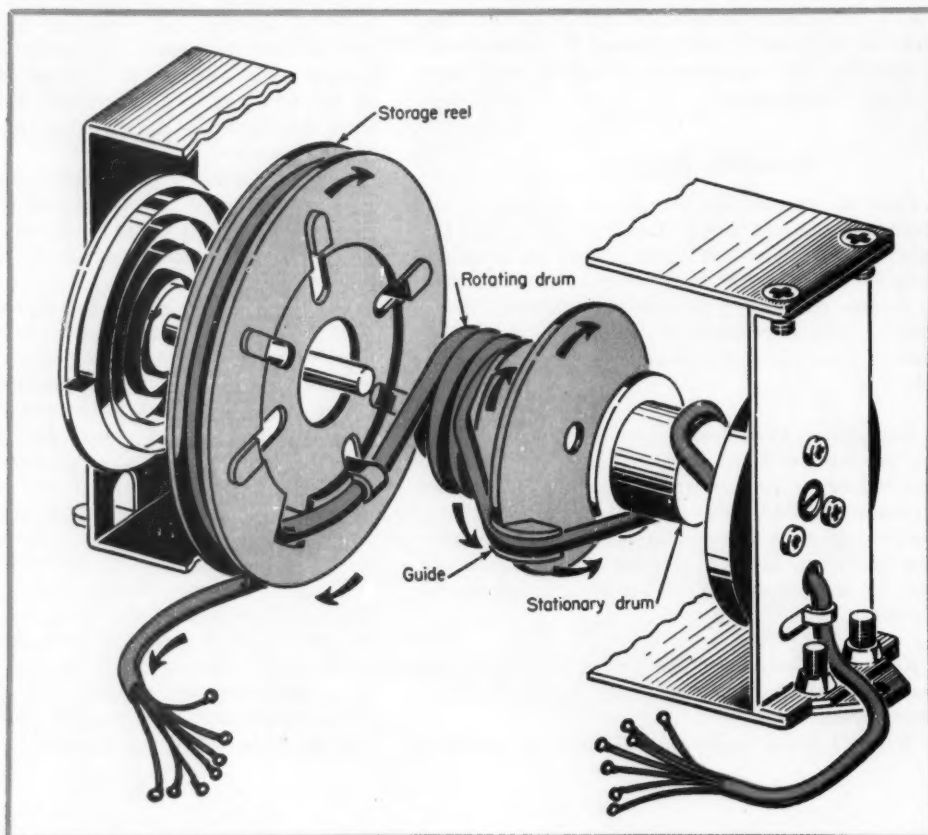
Capital investment may be an important aspect of the project proposal because of the company's financial situation and the general economic outlook. For example, if most of the normally available cash is tied up in inventory, it will be hard to sell a project involving a large capital outlay.

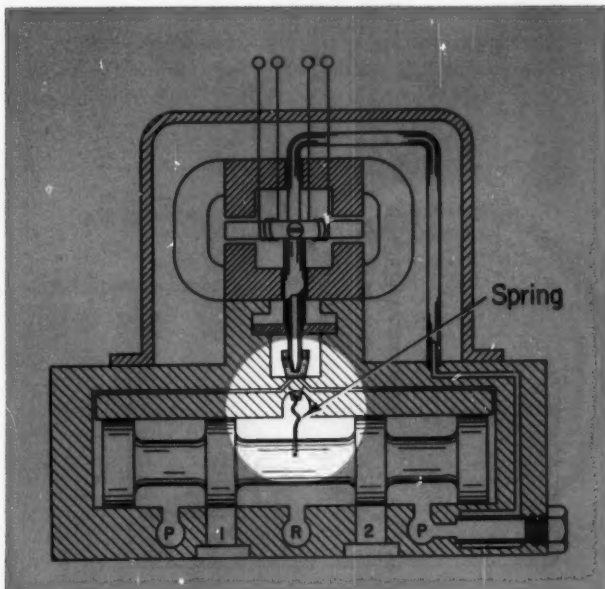
This type of situation can often be "softened" if the money is to be spent over a period of years, as is usually the case. Rather than emphasizing the fact that X thousands of dollars are needed, point out how much is needed in each six-month period to achieve major benefits for the company. If the money must be borrowed, the interest can be added to cost data to show how little the project's desirability is affected.

scanning the field for *ideas*

Unwrapping and rewinding of lead wires replace slip rings in a retractable cord reel. When the cord is withdrawn or returned to the storage reel, the short internal extension of the cord passes around

the guide from one small drum to the other. The total length of the wire on the small drums remains the same. Wire transfer principle employed in cord reel developed by Morey Corp., Chicago.

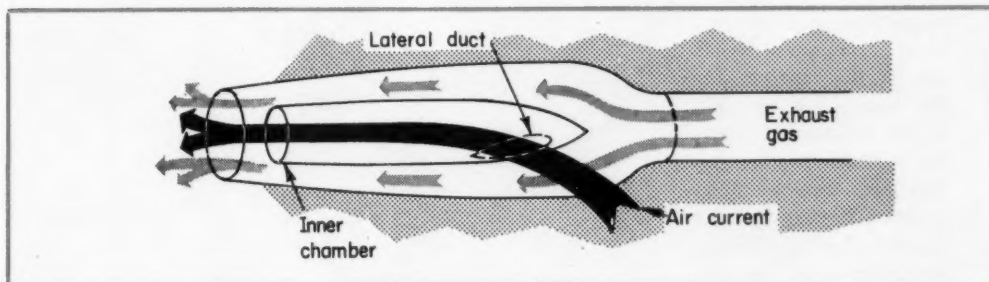




Interstage feedback spring

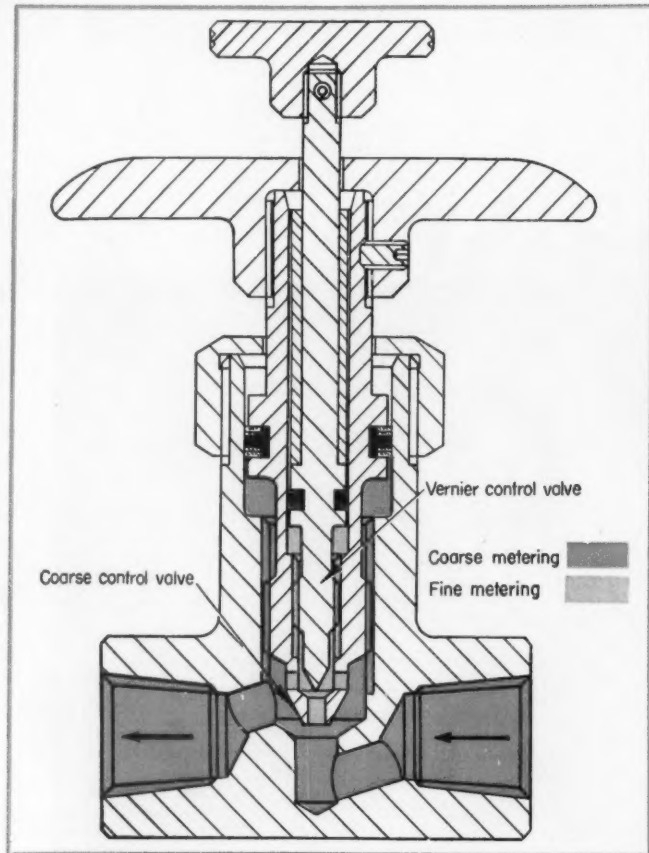
connects second stage spool and first stage jet pipe in a servovalve. Spool movement, in response to the torque motor-controlled movement of the jet pipe, produces a force to help center the jet pipe. Therefore, the spool assumes a position proportional in direction and magnitude to the input differential current in the torque motor. Interstage spring principle employed in servovalve developed by Raymond Atchley Inc., Los Angeles.

Exhaust suction is applied to an automobile engine by a venturi-arrangement muffler attached to the tailpipe. The forward motion of the automobile produces an air current through the muffler to provide a partial vacuum on the exhaust manifold. The engine carburetor and ignition settings must be adjusted for the revised exhaust condition. Principle employed in muffler used on sports car by Enzo Ferrari, Modena, Italy.

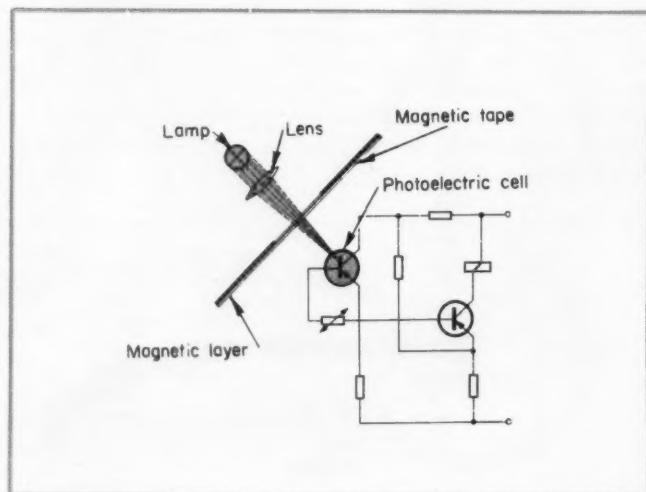


SCANNING THE FIELD FOR IDEAS

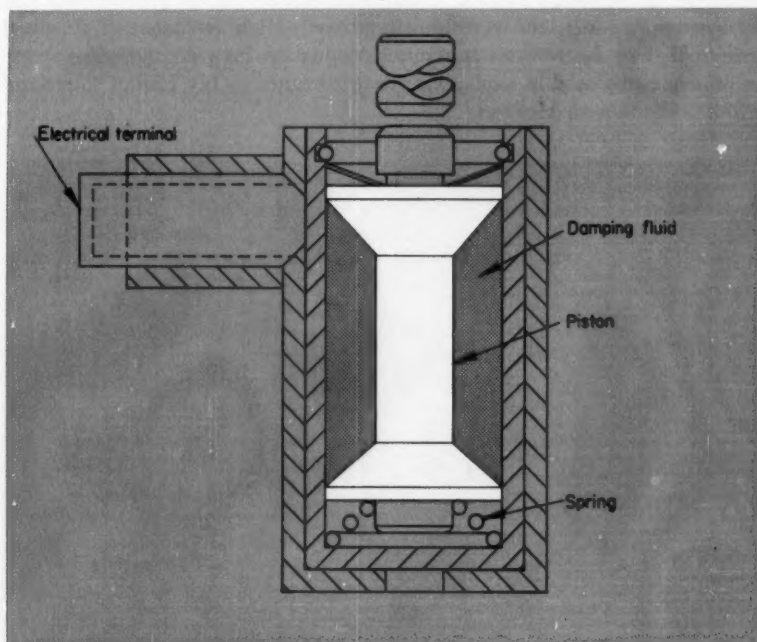
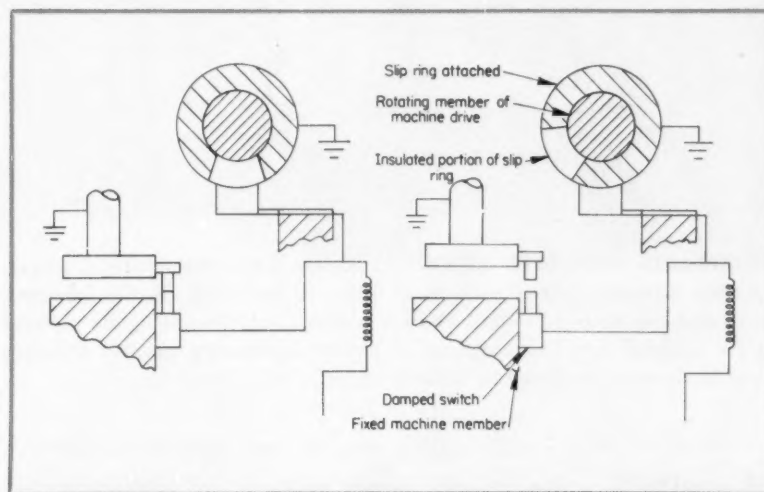
Concentric valves provide coarse plus vernier control of fluid flow. The seat for the vernier valve is contained within the coarse control valve. Principle employed in flow control valve developed by Kell-Strom Tool Co. Inc., Wethersfield, Mass.



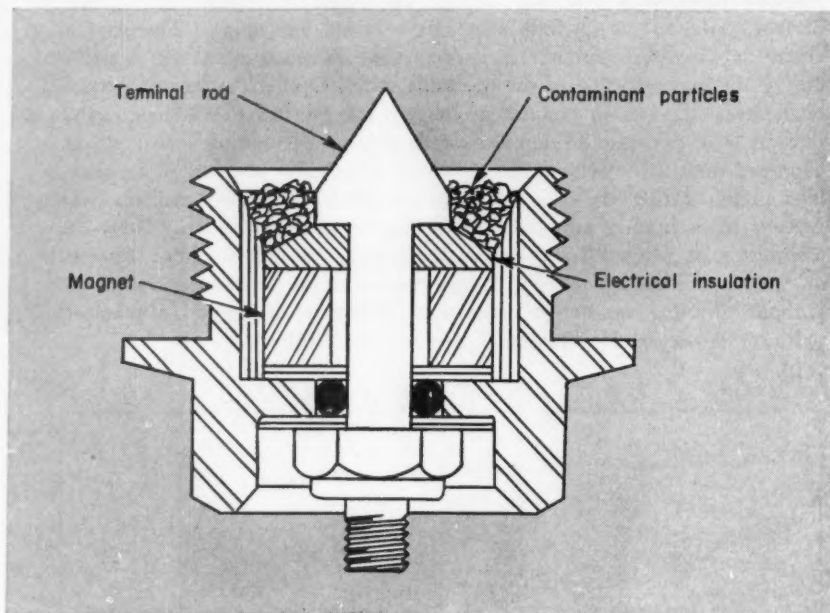
Removal of opaque layer permits light-beam control of magnetic tape. A solvent removes the opaque layer of magnetic material at any desired point. A photoelectric cell is normally shaded from a projected light beam by the magnetic tape. However, when a transparent portion of the tape passes the beam, the control circuit is energized and the recorder is stopped. Principle employed in recorder designed by Protona GmbH, Hamburg, Germany.



Viscous-damped switch senses an excess deflection but ignores normal variations to provide machine overload protection. The control circuit is grounded through any convenient machine operating member during the major portion of the operating cycle. During the sensing portion of the cycle the regular grounding circuit is opened, but an alternate circuit is completed through the damped-switch piston. The spring-loaded piston, depressed during contact, returns slowly to its original position. If an overload occurs during the next cycle, excess deflection in the machine will prevent the actuating arm from contacting the damped switch. Thus, the control circuit is opened and the relay actuated. Variations caused by wear or temperature change merely change the depressed position of the piston without affecting its normal operation. Principle employed in overload protector developed by Wintriss Controls, New York.

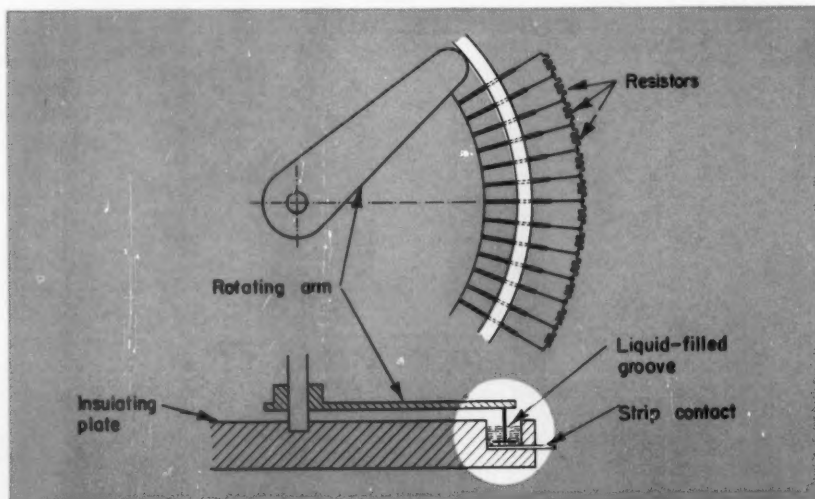


SCANNING THE FIELD FOR IDEAS



Contaminants complete circuit to actuate a warning device in a magnetic-particle collector. Metal particles or chips, in suspension in the lubricant, collect around the magnet. When there is sufficient accumulation, the particles bridge an insulated gap and complete an electrical-indicating circuit. Principle employed in detector developed by Lisle Corp., Clarinda, Iowa.

Liquid contacts provide constant contact resistance in a rotary potentiometer for use in a bridge circuit. The rotating arm makes contact with the resistors through the ethylene glycol-filled groove. High resistance of the fluid compared to that of the resistors minimizes conduction between successive strips. Contact principle employed in loudspeaker tester designed by NV Philips' Gloeilampenfabrieken, Eindhoven, Holland.



An Approximate Method of Calculating Shear and Bending in Free-Beam Structures *subjected to suddenly applied forces*

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Developed initially for missile design, the method presented here is generally applicable for calculating the dynamic response of beam-type structures subjected to sudden loads. The procedure is simpler than exact methods and is equally reliable in practical design.

PREDICTING the shear and bending stresses in a free, beam-type body in response to suddenly applied forces can be relatively simple. The method presented here was developed to find the stresses set up in missiles, but it is also applicable to other beam-type bodies and structures.

In missiles, the control forces from jet vanes or gimbaled nozzles constitute suddenly applied forces. The system of control forces causes the missile to translate and rotate about its center of gravity, and to vibrate as a free beam. The mass of the missile and its accelerations produce dynamic forces which must be combined with the control forces to determine net shear and bending moments.

Lagrange's equation of motion provides a powerful tool for solving dynamic response problems for free beam-type structures, as well as for systems with restrained motions. It is a compact method to express the equation of motion for each bending mode.

Difficulties in the application of Lagrangian techniques to engineering problems are encountered when the complete set of equations is excessively numerous, unwieldy, or difficult to solve. In these cases, approximations become desirable.

Actually, a free, beam-type structure has an infinite number of bending modes. For an exact solution, an equation would have to be written for each bending mode. Therefore, in the following discussion an approximate method is used. Only the first two fundamental bending modes are used. This gives satisfactory results because the first two bending modes produce large deflections and bending moments, while the higher bending modes produce small deflections and insignificant bending moments.

For additional simplification, assumed bending-mode shapes are used. This simplifies the mathematics throughout its development. Afterward, a solution of a typical problem using the assumed mode shape is compared with that obtained by the exact mode shape, thereby verifying the reliability of the approximation.

► Outline of Method

The mode acceleration method is used. It is applied in steps to find the components of local accelerations, which are then summed in accordance with

the principle of superposition to find total local accelerations along the structure. Total local accelerations are assumed to consist of the components resulting from:

1. Rigid body translation.
2. Unrestrained first mode bending caused by applied translation forces.
3. Rigid body rotation.
4. Unrestrained first rotational mode bending caused by applied couples.

Lagrangian techniques are simplified if the system is considered conservative. In this application, the system is justifiably conservative because structural damping or other possible damping (such as aerodynamic) have little effect on the maximum transient stress that occurs at the first peak. If subsequent oscillations are considered, the damping factors will provide substantial reductions in the bending moments.

The equations of motion for small vibrations of a conservative system are expressed by

$$M_i \frac{d^2 q_i}{dt^2} + K_i q_i = \Phi_i \quad (1)$$

where subscript i denotes the i th bending mode. Any q_i can be evaluated by Duhammel's integral,

$$q_i = \int_0^t \frac{\Phi_i}{\omega_i M_i} \sin(\omega_i t - \omega_i \tau) d\tau \quad (2)$$

Nomenclature

- A_z = Total local accelerations produced by combination of translation and rotational force systems, in. per sec²
- E = Modulus of elasticity, psi
- F = Force in direction normal to x axis, lb
- g = Acceleration of gravity, in. per sec²
- I = Moment of inertia, in.⁴
- I_y = Mass moment of inertia about y axis, lb-in.²/g
- K_i = Spring constant of unrestrained body, with subscript $i = A, S$ to denote first antisymmetrical and first symmetrical bending modes, respectively, lb per in.
- M = Total mass of body, lb/g
- M_i = Mass of unrestrained body, with subscript $i = A, S$ to denote first antisymmetrical and first symmetrical bending modes, respectively
- M_y = Bending moment about y axis, lb-in.
- m = Mass per inch of length along body, lb/g
- q_i = Generalized co-ordinate, with subscripts as, $q_s = A \sin \omega_s t$, to correspond with a particular bending mode
- S = Shear, lb
- T = Kinetic energy, in.-lb
- t, τ = Time, sec
- U = Strain energy, in.-lb
- W = Total weight of body, lb
- Z = Generalized co-ordinate for lateral deflections
- Φ_i = Generalized force, with subscript $i = A, S$, to denote first antisymmetrical and first symmetrical bending modes, respectively, lb
- ω = Natural frequency, radians per sec

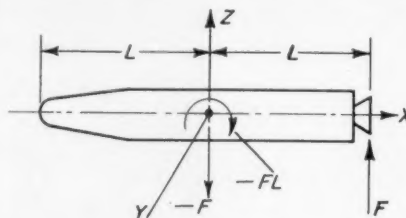


Fig. 1—Ballistic missile with suddenly applied force F .

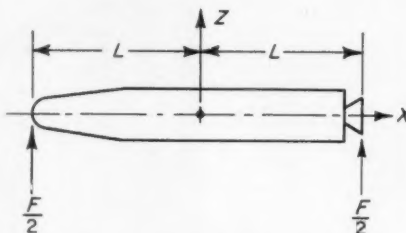


Fig. 2—Translation force system.

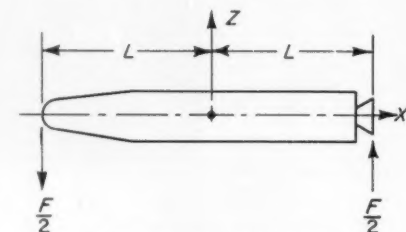


Fig. 3—Rotation force system.

For a step input between successive time intervals the integral yields the value,

$$q_i = \frac{\Phi_i}{\omega_i^2 M_i} (1 - \cos \omega_i t) \quad (3)$$

For $\omega_i^2 = K_i/M_i$, Equation 1 takes the form,

$$\frac{d^2 q_i}{dt^2} = \frac{\Phi_i}{M_i} - \omega_i^2 q_i \quad (4)$$

In some applications, such as a missile, a longitudinal load factor, N_x , may act concurrently with a control force. Under such conditions, the bending frequencies are reduced. Reductions in the bending frequencies for large longitudinal load factors should be estimated and used in such cases. A variety of engineering problems, such as airplane wing or fuselage bending, occur where no longitudinal loads are encountered. Here, longitudinal load factors are omitted to preserve simplicity.

► General Solution for Uniform Beam

The breakdown into components as outlined in the foregoing section separates the solution into two parts. Fig. 1 illustrates a ballistic missile with a normal force, F , applied at the aft end. This force is a sudden impulse and is caused by a jet vane or

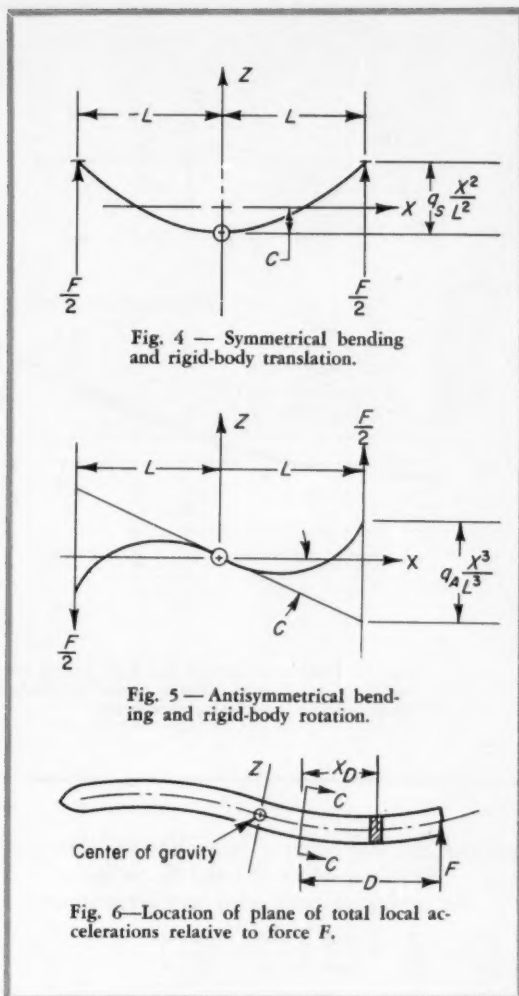


Fig. 4 — Symmetrical bending and rigid-body translation.

Fig. 5 — Antisymmetrical bending and rigid-body rotation.

Fig. 6—Location of plane of total local accelerations relative to force F .

gimbal nozzle. It can be resolved into two force systems, one of which affects the translation of the missile and the other its rotation.

Translation: Force F is moved to the center of gravity and the sign is reversed. The force $-F$ at the center of gravity is reacted by two forces, $F/2$, at either end of the missile, Fig. 2. The force system, consisting of these $F/2$ reactions to $-F$, will produce rigid-body translation and first-mode bending.

Rotation: The sign of moment FL produced by moving force F to the center of gravity is reversed. Moment $-FL$ is reacted by a couple of forces $\pm F/2$, Fig. 3. This force system consisting of the reactions to $-FL$ produces rigid-body rotation and first-mode rotational bending. The force systems of Fig. 2 and 3 when combined are obviously the same as initial force F .

If EI and m of the missile are constant, the first bending mode is symmetrical, and the first rotation bending mode is antisymmetrical. If EI and m are not constant, the bending modes would not be symmetrical and antisymmetrical, but the same

procedure of moving the applied force to the center of gravity and of determining the corresponding translation and couple forces would be used.

The mode shapes for bending would be determined by computing the deflection curves from the dynamic inertia forces for the respective conditions. By curve fitting, satisfactory mode shapes similar to the deflection curves can be selected. With modified mode shapes, actual mass distribution, and variable stiffness EI along the beam, the equations of motion can be written and solved by the method presented here.

Symmetrical Bending and Translation: In Fig. 4, the first bending mode is assumed to have the shape and generalized co-ordinate,

$$\begin{aligned} z &= q_s \left(\frac{x^2}{L^2} - C \right) \\ &= q_s \cdot \left(\frac{x^2}{L^2} - \frac{1}{3} \right) \end{aligned} \quad (5)$$

where $q_s = A \sin \omega_s t$. To evaluate $C = 1/3$, the equation for the sum of the dynamic inertia forces is equated to zero. That is,

$$F_z = \sum_{-L}^L m \frac{d^2 z}{dt^2} = 0 \quad (6)$$

The Lagrange equation which applies to symmetrical first mode bending is

$$\frac{d}{dt} \left(\frac{\partial T}{\partial \dot{q}_s} \right) + \frac{\partial U}{\partial q_s} = \Phi_s \quad (7)$$

Kinetic energy T , strain energy U , and other magnitudes for use in Equation 7 are

$$T = 2 \int_0^L \frac{m}{2} \left(\frac{dz}{dt} \right)^2 dx$$

$$U = 2 \int_0^L \frac{EI}{2} \left(\frac{d^2 z}{dx^2} \right)^2 dx$$

$$M_s = \frac{4M}{45}$$

$$K_s = \frac{8EI}{L^3}$$

When these quantities are put into Equation 7,

$$M_s \frac{d^2 q_s}{dt^2} + K_s q_s = \Phi_s \quad (8)$$

The generalized force Φ_s is a quantity multiplied by a small change in the generalized co-ordinate that does the same work as the product of the applied force and a small change in the generalized co-ordinate.

Since $F/2$ is applied at $X = L$,

$$\Phi_s = \frac{2F}{3} \quad (9)$$

If Φ_s is a step input,

$$\frac{d^2 q_s}{dt^2} = \frac{\Phi_s}{M_s} \cos \omega_s t \quad (10)$$

The acceleration for the rigid body in translation

is F/M ; hence, the total local accelerations for symmetrical bending plus rigid body translation are

$$\frac{d^2 Z_B}{dt^2} = \frac{F}{M} + \frac{\Phi_B}{M_B} \cos \omega_B t \left(\frac{X^2}{L^2} - \frac{1}{3} \right) \quad (11)$$

Antisymmetrical Bending and Rotation: In Fig. 5, the first antisymmetrical bending mode is assumed to have the shape and generalized co-ordinate,

$$\begin{aligned} Z &= q_A \left(\frac{X^3}{L^3} - CX \right) \\ &= q_A \left(\frac{X^3}{L^3} - \frac{3X}{5L} \right) \end{aligned} \quad (12)$$

in which the evaluation of C is made by equating to zero the sum of the dynamic inertia rolling moments for each half of the system, or

$$(\text{Half}) M_y = \sum_0^L m \frac{d^2 Z}{dt^2} X = 0 \quad (13)$$

Kinetic energy T , strain energy U , and other relationships for substitution into a Lagrange equation like Equation 7 are

$$T = \frac{2M}{175} \left(\frac{dq_A}{dt} \right)^2$$

$$M_A = \frac{4M}{175}$$

$$U = \frac{12EI}{L^3} q_A^2$$

$$K_A = \frac{24EI}{L^3}$$

The accelerations for the rigid body in rotation are FLX/I_y , so that the total local accelerations for antisymmetrical bending plus rotation are

$$\frac{d^2 Z_A}{dt^2} = \frac{FL}{I_y} X + \frac{\Phi_A}{M_A} \cos \omega_A t \left(\frac{X^3}{L^3} - \frac{3X}{5L} \right) \quad (14)$$

Final Approximate Equations

The total local accelerations are the sum, A_z , of Equations 11 and 14. In Fig. 6, X_D is the distance from a local force, $m A_z$, to any section C-C. The net shear at the section is

$$S = F + \sum_{X=C-C}^{X=L} m A_z \quad (15)$$

and the net moment at the section is

$$M_y = FD + \sum_{X=C-C}^{X=L} m A_z X_D \quad (16)$$

Example 1: A simple case in which a normal step input is applied at the center of gravity of a uniform beam will illustrate the calculation procedure, Fig. 7a. For this case, the rotation terms drop out and Equation 11 expresses the total A_z . Also, $\Phi_B = -F/3$ and $M_B = 4M/45$.

Maximum accelerations occur at time $t = \pi/\omega_B$

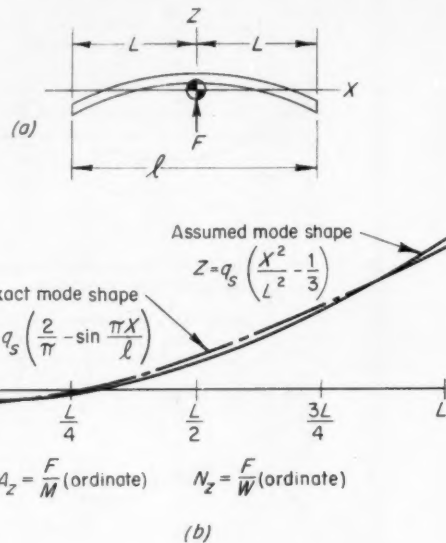


Fig. 7—Total accelerations and load factors for maximum bending moment at center of gravity when force is applied at that point.

provided the step input F is applied for time t or longer. For these values of t and F , $\cos \omega_B t = -1$, and the maximum total local accelerations are

$$\frac{d^2 Z}{dt^2} = \frac{F}{M} + \frac{15F}{4M} \left(\frac{X^2}{L^2} - \frac{1}{3} \right) \quad (17)$$

and the total local load factors, N_z , are

$$N_z = \frac{F}{W} + \frac{15F}{4W} \left(\frac{X^2}{L^2} - \frac{1}{3} \right) \quad (18)$$

where W is the total weight.

A curve for the total accelerations and load factors is shown by Fig. 7b. The maximum bending moment occurs at the center of gravity and has a magnitude of $0.406 FL$, lb-in.

Example 2: Suppose a normal step input F is applied at an end of a uniform beam for a time t equal to or greater than π/ω_B , Fig. 8a, and $\omega_A \approx 3\omega_B$. Again, the maximum bending moment occurs at the CG. In this example, its magnitude is $-0.562 FL$, lb-in.

Under these conditions at time t , $\cos \omega_B t = -1$, $\cos \omega_A t \approx -1$, and the critical total local accelerations are

$$\begin{aligned} A_z &= \frac{F}{M} - \frac{\Phi_B}{M_B} \left(\frac{X^2}{L^2} - \frac{1}{3} \right) + \frac{FLX}{I_y} - \\ &\quad \frac{\Phi_A}{M_A} \left(\frac{X^3}{L^3} - \frac{3X}{5L} \right) \end{aligned}$$

where $\Phi_B = 2F/3$, $M_B = 4M/45$, $\Phi_A = 2F/5$, $M_A = 4M/175$, and $I_y = ML^2/3$. Critical total local load factors are

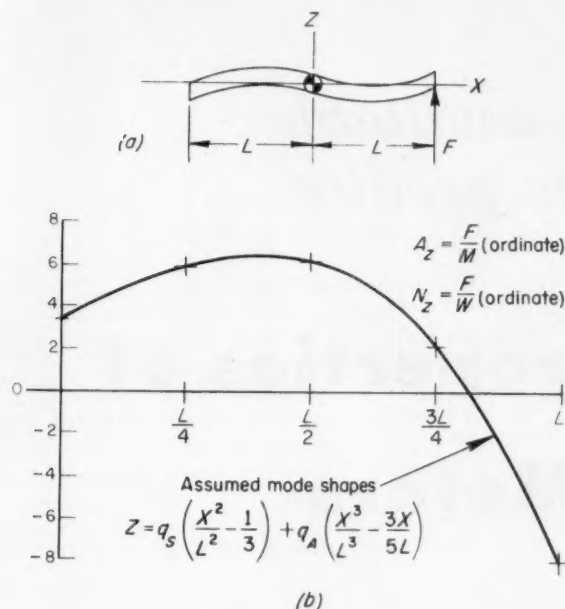


Fig. 8—Total accelerations and load factors for maximum bending moment at center of gravity when force is applied at end.

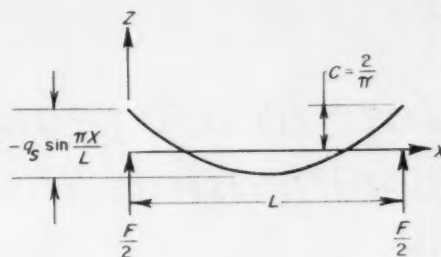


Fig. 9—Exact shape of first bending mode for an unrestrained symmetrical beam.

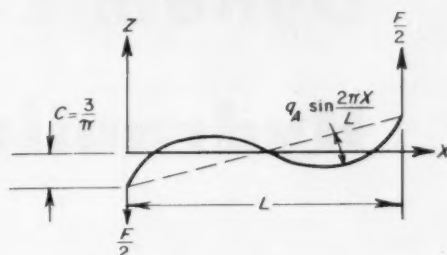


Fig. 10—Exact shape of second bending mode for an unrestrained symmetrical beam.

$$N_z = \frac{F}{W} - \frac{15F}{2W} \left(\frac{X^2}{L^2} - \frac{1}{3} \right) + \frac{3F}{WL} X - \frac{35F}{2W} \left(\frac{X^3}{L^3} - \frac{3X}{5L} \right)$$

► Lagrange's Equations for Exact Mode Shapes

Exact shape of first bending mode for an unrestrained uniform beam, Fig. 9, is expressed by

$$Z = q_s \left(\frac{2}{\pi} - \sin \frac{\pi X}{L} \right) \quad (19)$$

where L now designates total length, as in Fig. 9 and 10 and in all of the following equations.

When Equation 19 is used in the same manner as Equation 5, an equation of the form of Equations 1 and 8 is obtained. Exact relationships for kinetic energy T , strain energy U , and other quantities are

$$T = \frac{(\pi^2 - 8)mL}{4\pi^2} \left(\frac{dq_s}{dt} \right)^2$$

$$M_s = \frac{1.9}{2\pi^2} mL$$

$$U = \frac{EI\pi^4}{4L^3} q_s^2$$

$$K_s = \frac{EI\pi^4}{2L^3}$$

$$\Phi_s = \frac{2F}{\pi}$$

Equation 19 for exact mode shape is shown in

Fig. 7b for comparison with Equation 5 of the approximate analysis.

Similarly, the exact mode shape of the second bending mode for an unrestrained uniform beam, Fig. 10, is expressed by

$$Z = q_A \left[\sin \frac{2\pi X}{L} - \frac{3}{\pi} \left(1 - \frac{2X}{L} \right) \right] \quad (20)$$

In this case, the relationships needed to derive an equation in the form of Equation 1 are

$$T = \left(\frac{1}{2} - \frac{3}{\pi^2} \right) \frac{mL}{\pi^2} \left(\frac{dq_A}{dt} \right)^2$$

$$M_A = \frac{(\pi^2 - 6)mL}{2\pi^2}$$

$$U = \frac{4EI\pi^4}{L^3} q_A^2$$

$$K_A = \frac{8EI\pi^4}{L^3}$$

$$\Phi_A = \frac{3F}{\pi}$$

The closeness with which the curve for the assumed mode shape, Fig. 7b, parallels that of the exact mode shape is indicative of the reliability of the approximate method.

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*How to use readily available
specification data to predict . . .*

Dynamic Properties of Hydraulic Motors

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CLOSED - LOOP control provides accurate performance because it continually tries to correct any errors that exist. However, it can also cause unstable performance, or oscillation, by over-correction.

In a control system requiring high accuracy and fast response, a piston-type hydraulic motor is often the best actuator.

Prediction of the accuracy and stability of a closed loop control system requires knowledge of the dynamic properties of the actuator and load.

This article discusses methods for predicting the natural resonant frequency and damping ratio of a hydraulic motor and load. Additionally, it shows how the predicted values can be confirmed by measured data.

Theoretical Performance

Natural resonant frequency may be described as the frequency at which a frictionless second-order system oscillates. If friction is added, the frequency of oscillation changes slightly. With friction present, the frequency of oscillation is known as the damped resonant frequency. Viscous drag is one type of friction.

Critical damping produces a response with no overshoot. Damping ratio ζ is the ratio of actual damping to the damping necessary to produce a critically damped response in a second-order system. Fig. 1 shows the effect of damping ratio on transient response. The underdamped response occurs for $\zeta < 1$, while the overdamped response occurs for $\zeta > 1$.

Damping ratio and resonant frequency are characteristics of the steady-state and dynamic behavior

of a device which can be described by a transfer function. Fundamentally, the transfer function of a device is its output divided by its input. For a hydraulic motor, the desired output may be either shaft position or speed. The input is fluid flow to the motor.

In deriving the transfer function for a hydraulic motor, the total fluid flow is assumed to be the sum of three component flows. These are flow due to motion of the motor, leakage flow around the motor, and fluid-compressibility flow.

Fig. 2 shows a hydraulic motor driving an inertia-plus-viscous-drag-load through gearing. The fluid power source might be a variable displacement pump or a servovalve with constant pressure supply as shown. If viscous drag is negligible, the speed transfer function of the hydraulic motor and load, Fig. 2 is

$$\frac{\omega_1(s)}{X(s)} = \frac{K}{\left(\frac{1}{\omega_n}\right)^2 s^2 + \frac{2\zeta}{\omega_n} s + 1} \quad (1)$$

where

$$K = \frac{C_1}{\frac{2\pi}{d_m} W}$$

$$\left(\frac{1}{\omega_n}\right)^2 = \frac{J_1 + \frac{J_2}{n^2}}{K_c W}$$

$$\frac{2\zeta}{\omega_n} = \frac{\left(J_1 + \frac{J_2}{n^2}\right) \left(K_l + C_2\right) + \frac{B_1 + \frac{B_2}{n^2}}{K_c}}{W}$$

$$W = \left(B_1 + \frac{B_2}{n^2}\right) \left(K_l + C_2\right) + \left(\frac{d_m}{2\pi}\right)^2$$

Then,

$$\omega_n = \frac{d_m}{2\pi} \sqrt{\frac{K_c}{J_1 + \frac{J_2}{n^2}}} \quad (2)$$

and

$$\zeta = \frac{\left(J_1 + \frac{J_2}{n^2}\right) \left(K_l + C_2\right)}{2 \left(\frac{d_m}{2\pi}\right)^2} \omega_n \quad (3)$$

Frequency f_n can be obtained from ω_n .

$$f_n = \frac{\omega_n}{2\pi} \quad (4)$$

In general, the natural resonant frequency should be as high as possible. A natural resonant frequency of 10 cps for a motor plus load is usually sufficient for applications where snappy control action plus moderately high accuracy are desired. In many applications, however, the desired control results can be

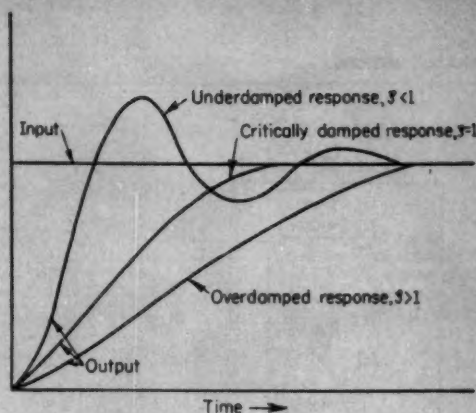


Fig. 1—Typical step response of a second-order system. A critically damped output responds as fast as possible without overshoot.

Nomenclature

- A_o = Amplitude of first overshoot, rpm
- A_u = Amplitude of first undershoot, rpm
- E_1 = Viscous drag coefficient of hydraulic motor plus any other viscous drag on its shaft, in.-lb per radian per sec
- B_2 = Viscous drag coefficient of load plus any other viscous drag on its shaft, in.-lb per radian per sec
- C_1 = Flow-versus-position characteristic of hydraulic power source, cu in. per sec per in.
- C_2 = Flow-versus-pressure characteristic of hydraulic power source, cu in. per sec per psi
- d_m = Displacement of hydraulic motor, cu in. per revolution
- f_d = Damped resonant frequency, cps
- f_n = Natural resonant frequency, cps
- g = Acceleration due to gravity = 386 in. per sec²
- J_1 = Inertia of hydraulic motor rotor plus all other inertia on motor shaft, divided by g , lb-in.² per in. per sec²
- J_2 = Inertia of load plus all other inertia on load shaft, divided by g , lb-in.² per in. per sec²
- K_c = Fluid compressibility constant, psi per cu in.
= $4\beta/V$ for four-way servovalve and constant pressure supply as power source
= β/V for variable-stroke pump as power source
- K_l = Leakage characteristic of hydraulic motor, cu in. per sec per psi
- N = Hydraulic motor shaft speed, rpm
- n = Ratio of motor-shaft rotation to load-shaft rotation
- P_n = No-load running pressure, psi
- P_s = Supply pressure, psi
- s = Derivative with respect to time, sec⁻¹
- T_o = Time of first overshoot, sec
- T_u = Time of first undershoot, sec
- V = Total volume of fluid under compression, cu in.
- X = Control device displacement from neutral position, in.
- β = Bulk modulus of fluid, psi
= 1.7×10^5 , average value for oil
- ζ = Damping ratio
- θ_1 = Angular position of hydraulic motor shaft, radians
- ω_1 = Angular velocity of hydraulic motor shaft, radians per sec
- ω_n = Natural resonant frequency, radians per sec

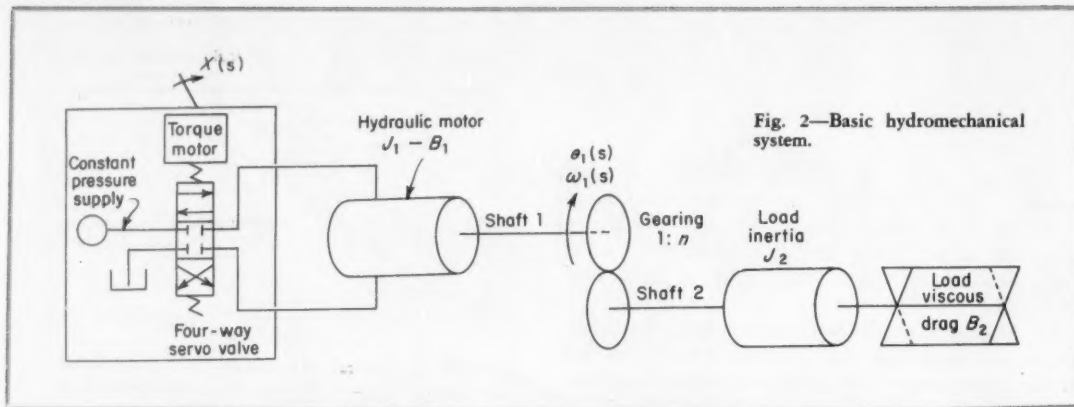


Fig. 2—Basic hydromechanical system.

obtained with a lower motor-load resonance. Such applications are frequently characterized by maximum speeds or cycling rates which are low. The accuracy requirements may be relatively high. Equation 2 shows that the spring of the oil must be high and the inertia of the system low to obtain high natural resonant frequency. Thus, the volume of fluid under compression must be kept to a minimum and the oil-circuit piping between the fluid source and hydraulic motor must be rigid.

In many control applications, shaft position rather than speed must be predicted. The speed transfer function can be converted to a position transfer function by integration of Equation 1:

$$\frac{\theta_1(s)}{X(s)} = \left(\frac{C_1}{d_m/2\pi} \right) / \left[s \frac{J_1 + \frac{J_2}{n^2}}{K_c \left(\frac{d_m}{2\pi} \right)^2 s^2 + \left(J_1 + \frac{J_2}{n^2} \right) \left(\frac{K_l + C_2}{\left(\frac{d_m}{2\pi} \right)^2} \right) s + 1} \right] \quad (5)$$

Practical Example

Predict the damping ratio and natural resonant frequency of a 3 hp, 800 psi piston-type hydraulic

motor. Supply pressure is 1700 psi. The four-way servovalve is rated at 8 gpm at a displacement of 0.015 in. and a pressure drop of 1000 psi.

The specifications of the hydraulic motor are shown in Table 1.

The volume of fluid under compression is 9 cu in. This is the total volume of oil between the servovalve and motor plus the oil contained in the internal control circuit of the motor. There is no external load.

Solution: Since valve flow is proportional to the square root of the pressure drop, the valve flow at 1700 psi = $8(1700/1000)^{1/2} = 10.5$ gpm. The valve flow-versus-position characteristic may be calculated as:

$$C_1 = \frac{10.5(231)}{0.015(60)} = 2.7 \times 10^3 \text{ cu in. per sec per in.}$$

On servovalves of this type, 1.5×10^{-3} in. is the approximate stroke necessary to develop full system pressure across the load when the load position is held stationary. Near the neutral position of the valve, the approximate flow-versus-pressure characteristic is

$$C_2 = \frac{1.5 \times 10^{-3} C_1}{P_s} = \frac{1.5 \times 10^{-3}(2.7 \times 10^3)}{1700} = 2.4 \times 10^{-3} \text{ cu in. per sec per psi}$$

The fluid compressibility constant $K_c = 4\beta/V = 4(1.7 \times 10^5)/9 = 7.6 \times 10^4$ psi per cu in. Viscous drag $B_1 = [(d_m/2\pi)/(P_s)]/[(2\pi/60)N] = [(1/2\pi)/100]/[2\pi/60]1100 = 0.14$ in.-lb per radians per sec.

Leakage can be determined from the motor specification data. Assume that the motor is stopping, then leakage = $0.005 \times 1620 \text{ rpm} \times 1 \text{ cu in. per revolution} = 8.1 \text{ cu in. per min per 1000 psi}$. Leakage characteristic $K_l = (8.1/60)/1000 = 1.3 \times 10^{-4}$ cu in. per sec per psi.

Table 1—Hydraulic Motor Specifications

Normal pressure	800 psi
Rated speed	1620 rpm
Displacement	1 cu in. per revolution
Mass moment of inertia	0.04 lb-in.-sec ²
No-load running pressure	100 psi at 1100 rpm
Slip, per cent of motor flow at rated speed per 1000 psi pressure drop across motor	
Motor stopped	Up to 0.5 per cent
Motor running	Up to 2 per cent

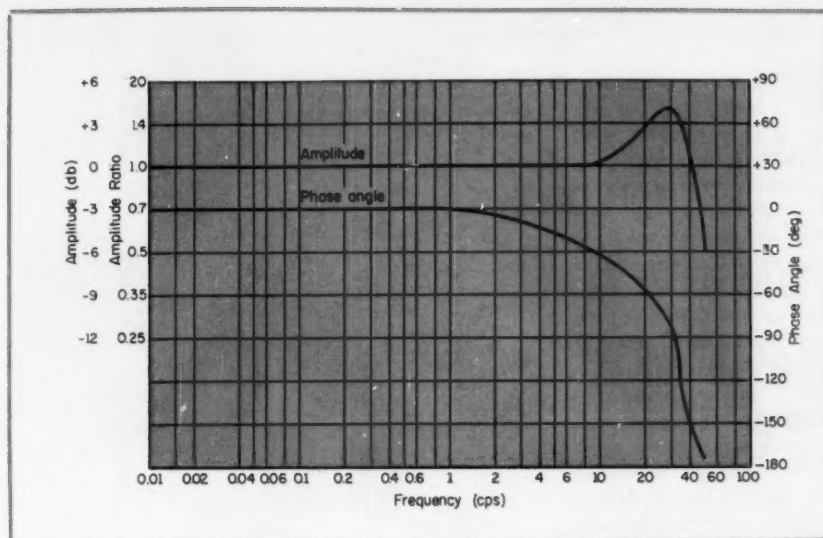


Fig. 3 — Open-loop frequency response of hydraulic motor for ± 5 per cent displacement of valve.

Table 2—Comparison of Performance Values

Source of Data	Resonant Frequency, f_n	Damping Ratio, ζ
Predicted (from specifications)	35	0.43
Frequency response test	33	0.32
Transient response test	31	0.30
Calculated from measure data	35	0.33

From Equation 2,

$$\omega_n = \frac{1}{2\pi} \sqrt{\frac{7.6 \times 10^4}{0.04 + 0}}$$

$$= 220 \text{ radians per sec}$$

or

$$f_n = \frac{220}{2\pi}$$

$$= 35 \text{ cps}$$

From Equation 3,

$$\zeta = \frac{(0.04 + 0)(1.3 \times 10^{-4} + 2.4 \times 10^{-3})(220)}{2(2.5 \times 10^{-2})}$$

$$= 0.43$$

Compressibility of the oil column and the rotor inertia of the motor are the predominant factors determining the natural resonant frequency. A natural resonant frequency of 35 cps is high enough to insure snappy, accurate response from the motor.

Damping is primarily due to the flow-pressure characteristic, C_2 , which is a characteristic of the fluid power source—a servo valve in this example.

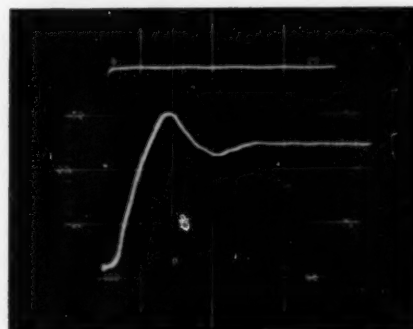


Fig. 4—Motor speed transient response of hydraulic motor for step input signal to servo valve. Time scale = 0.005 sec per division.

The damping produced by the leakage of the motor is only 5 per cent of the total damping. If the 2 per cent value for the motor slip had been used instead of 0.5 per cent, the motor would have contributed only 20 per cent of the total damping, to produce a damping ratio of 0.5. Since the damping comes essentially from the fluid power source, the accuracy of an estimated damping ratio is no better than the approximation for C_2 . Because damping is a power loss which results from simultaneous flow and pressure drop, C_2 is a minimum when the valve is in its neutral position.

Measured Data

Fig. 3 is a plot of a frequency response test conducted on the hydraulic system described in the illustrative example. This frequency response plot is typical of an underdamped second-order system. The oscillogram, Fig. 4, illustrates the transient response of this same system. Fig. 4 shows that the motor speed exhibits a definite underdamped

response to a step-input signal instructing the hydraulic motor to stop. This is in agreement with the underdamped characteristic of the frequency response. The motor speed response to a step signal telling it to start indicates greater damping. This is consistent with the fact that for most servovalves, C_2 , and hence damping, increases as the servo valve opens.

The natural resonant frequency and damping ratio of a system may be determined from either frequency response or transient response data.

Frequency-Response Method: Fig. 3 shows a peak of 4 decibels in the amplitude-ratio curve at a damped resonant frequency of 29 cps. Reference to texts on servomechanism theory shows that a peaking of 4 db in the amplitude ratio of a second-order system is consistent with a damping ratio of approximately 0.32. The natural resonant frequency may be determined from the frequency response data by

$$\begin{aligned} f_n &= \frac{f_d}{\sqrt{1 - 2\zeta^2}} \\ &= \frac{29}{\sqrt{1 - 2(0.32)^2}} \\ &= 33 \text{ cps} \end{aligned} \quad (6)$$

Transient-Response Method: Damping ratio may be determined from transient response data by using the log-decrement method. Referring to the transient response of motor speed to a signal com-

manding it to stop, Fig. 4, the damping ratio computed by

$$\begin{aligned} \zeta &= \sqrt{\frac{1}{\frac{\pi^2}{Z^2} + 1}} \\ &= 0.30 \end{aligned} \quad (7)$$

where $Z = \ln(A_0/A_n)$.

The resonant frequency may be calculated from this same transient response oscillogram by

$$\begin{aligned} f_n &= \frac{1}{2\sqrt{1 - \zeta^2} (T_u - T_0)} \\ &= \frac{1}{2\sqrt{1 - 0.30^2} (0.017)} \\ &= 31 \text{ cps} \end{aligned} \quad (8)$$

Measured-Data Method: The measured flow-versus-displacement characteristic, C_1 , of the servo-valve is 3.1×10^3 cu in. per sec per in. Its measured flow-versus-pressure characteristic, C_2 , is 1.1×10^{-3} cu in. per sec per psi. Using these values in Equations 2, 3, and 4, $f_n = 35$ cps; $\zeta = 0.33$.

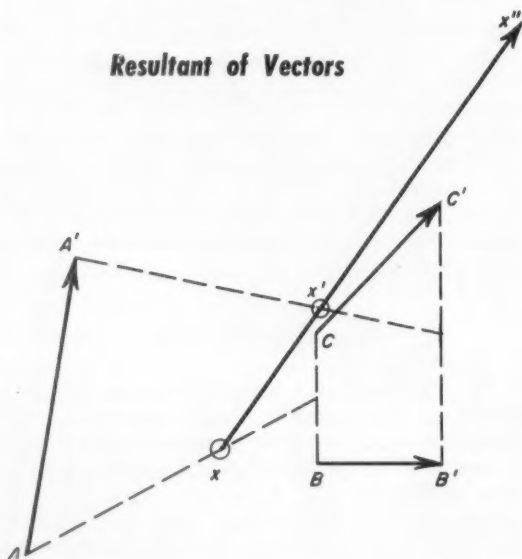
The values obtained by the various methods are shown in Table 2. Natural resonant frequency and damping ratio calculated from the specifications ordinarily available for the hydraulic motor are a close approximation of the values determined by use of measured data.

ACKNOWLEDGMENT

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Tips and Techniques

Resultant of Vectors

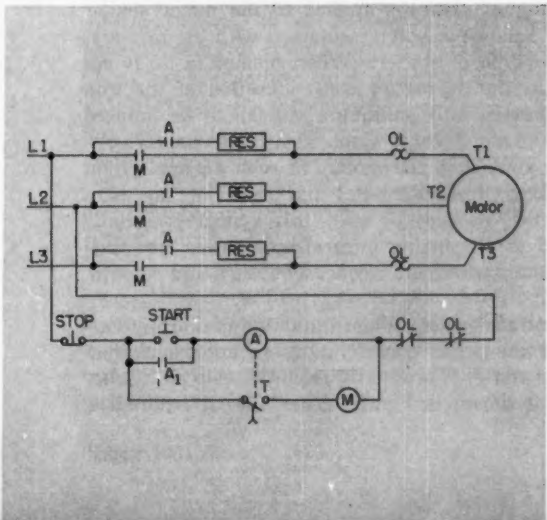
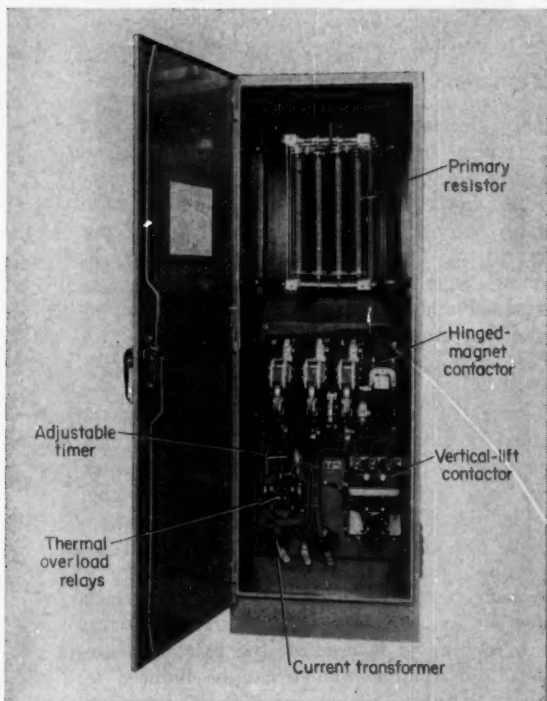
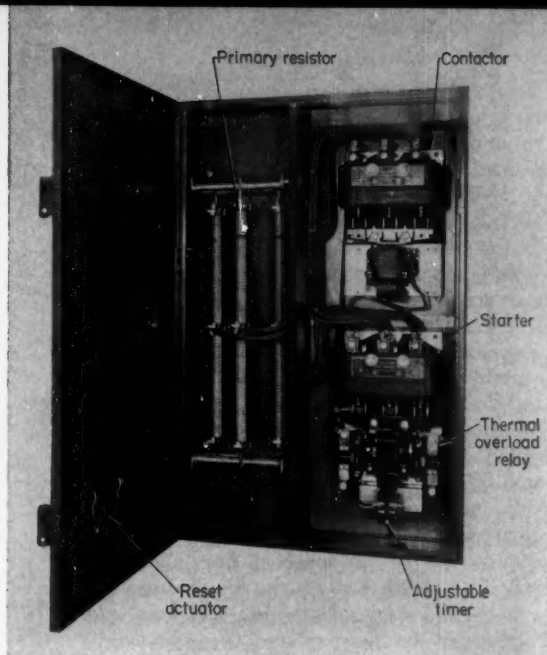


The following example illustrates a graphical method of finding the resultant of any number of vectors. Assume that vectors AA' , BB' , CC' are given.

1. Find the centroid, x , of the starting points of the three known vectors.
2. Find the centroid, x' , of the terminal points of the vectors.
3. Connect both centroids. Direction of the resultant is from the centroid of the starting points to that of the stopping points.
4. Measure xx' and multiply this dimension by the number of known vectors—in this case, three—to find the length of the resultant vector, xx'' .

A method for finding the C. G. of a number of points was published in *MACHINE DESIGN*, May 3, 1956, p. 104.—W. R. BRUBAKER, Fort Worth, Tex.

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AC Motor Control - 3

Reduced-Voltage Starting

How to select controls for squirrel-cage motors

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PUTTING certain machines or loads in motion may require a gentle start and smooth acceleration up to full speed. Starters that provide such cushioned action are frequently used to control hoist, pump, or conveyor drives. In addition to the demands of particular loads, power company regulations may limit the current surge or voltage fluctuation that may be imposed on the power supply during motor starting.

Two basic methods are available for obtaining cushioned motor starts, both of which meet load and power-supply requirements. Variations of these methods provide other features that permit a wide variety of applications to be satisfied.

Reduced-Voltage Starters

Three types of starters which are designed to apply reduced values of line voltage to motor windings

Fig. 1—Typical primary-resistor starters and basic circuit application for a three-phase squirrel-cage motor. The starter with the hinged-magnet type contactor uses transformers to supply current to conventional size thermal overload relays.

are: 1. Primary resistor. 2. Primary reactor. 3. Auto-transformer. When the power supply is not adequate for heavy initial surges of starting current, these starter types will often permit available motors to be used.

Primary Resistor: The most common type of reduced-voltage starter is the primary-resistor starter.

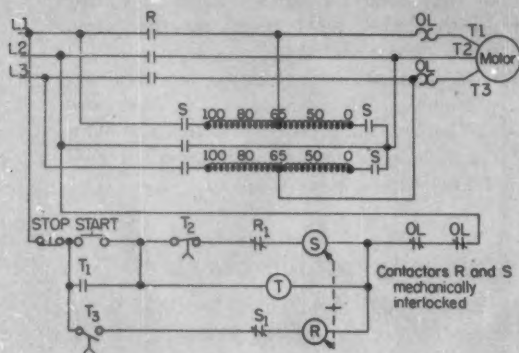
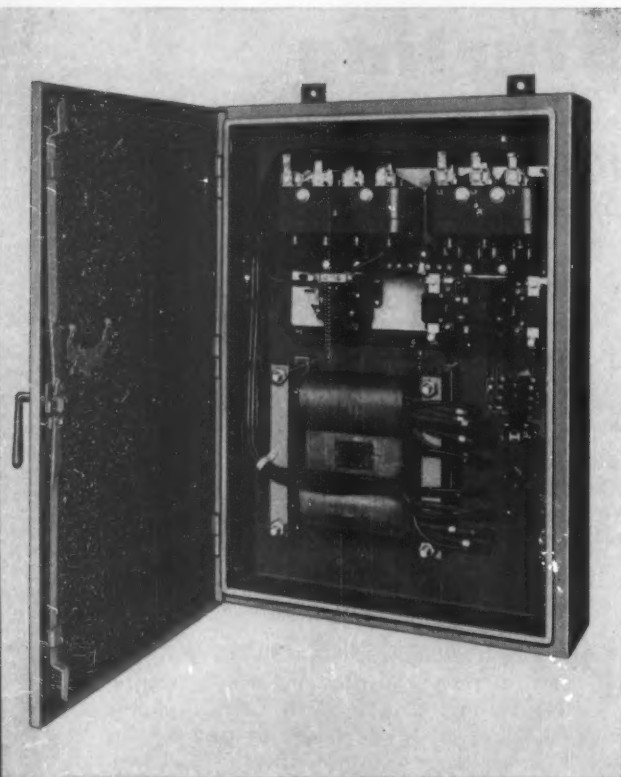


Fig. 2—Typical autotransformer reduced-voltage starter and basic circuit application for a three-phase squirrel-cage motor.

Two variations are shown in Fig. 1. Basic operation of these starters is illustrated by the schematic in Fig. 1. When the *start* button is pressed, contactor A closes and applies power to the motor through the resistors. Timer T begins to time out and closes after the proper time interval. When the timer contacts close, M contactor is energized. The M contacts short out the resistors and apply full voltage to the motor.

The primary-resistor reduced-voltage starter, especially in the smaller sizes, is the least expensive type because of its inherent simplicity. Relatively high breakdown torque is provided, and motor torque is constantly increased as the motor speeds up.

Smooth, cushioned starting and acceleration are obtained without a transition period (during which the motor would be disconnected from the line). Acceleration is smooth because the motor draws less current as it gains speed. As current decreases, voltage drop across the resistors also decreases, while voltage at the motor terminals increases. When extra smooth acceleration is desired, multiple-point starting is possible by using extra sets of resistors and contactors.

Primary Reactor: The main advantages of the primary reactor over other types of reduced-voltage starting are the somewhat higher maximum starting torque and lower starting losses. Ordinarily, these advantages are not sufficient to warrant use of the primary reactor. Consequently, it is used mainly in high-voltage applications because the reactor is self-contained and presents none of the insulation problems that would be involved in mounting resistors in such applications. A schematic diagram for this type of starter would be essentially the same as the one in Fig. 1 except that reactors are substituted for the resistors.

An interesting exception to the primary reactor is found in a special crane controller. A saturable reactor is placed in the power circuit to reduce voltage to the motor and so cushion the starting action. The length of time before full voltage is applied to the motor is controlled by a rheostat which regulates the amount of dc applied to the reactor. When minimum dc is applied, the reactor is unsaturated, and a large voltage can be induced in the ac reactor coils. The balance of the line voltage, a minimum value, is applied to the motor similar to the balance of voltage obtained with the primary-resistor type of starter. When maximum dc is applied to the dc reactor coil, saturation of the iron core permits only minimum voltage to be induced by ac in the ac coils. Consequently, maximum voltage is applied to the motor. In such an application the dc control eliminates the need for an extra contactor. Because of cost, this system is usually limited to the smaller integral-horsepower, low-voltage motors which are frequently started and stopped.

Autotransformer: When limitation of starting current is the prime consideration, an autotransformer type of starter is ordinarily required. A typical schematic is shown in Fig. 2. When the *start* button is

pressed, contactor S is energized. Closing of the S contacts places reduced voltage on the motor and opens electrical interlock S₁ in the coil circuit of the run contactor. Simultaneously, timing relay T is energized, and its instantaneous contact closes the holding circuit for both S and T coils. Also, the two time-delay contacts start to time out. At the end of the time interval, T₂, normally closed, opens to de-energize contactor S and disconnect the transformer. Normally open contact T₃ closes in the coil circuit of contactor R. After S has dropped out and S₁ closes, then R closes and applies full voltage to the motor. Electrical interlock R₁ opens as a safeguard. Mechanical interlocks are also incorporated in the control assembly between start and run contactors.

The autotransformer starter provides low line current and low losses during starting. Maximum starting torque is low, but transformer action provides sufficient torque per ampere of line current for starting heavily loaded equipment, such as a loaded belt conveyor, with minimum drain on the power supply.

In the standard autotransformer circuit there is a moment of transition which occurs just after the transformer is disconnected from the line and just prior to the closing of the main contactor. During this moment, the motor is actually disconnected from the power line. When the main contacts close and apply full voltage to the motor, a high transient current can be produced which might be excessive for either the power supply or the driven machinery. This momentary transition, however, can be eliminated with a special circuit known as the Korndorfer circuit.

Comparison of Starter Types: All reduced-voltage starters function to cushion the drive against mechanical shock and the power system against high starting currents. Because of its closed transition and smoother start, the primary-resistor type is preferred if it can furnish ample torque within allowable current limits. If open transition is acceptable, the autotransformer, which develops more torque per ampere of line current, is used where torque is important. Conventional use of primary-reactor starters is in high-voltage starters where inherent insulation benefits permit better construction.

If severe limitations are imposed on starting currents, values of resistance for a primary-resistor starter may be required which will be great enough to reduce torque below a point of positive starting. In such cases either a reactor or autotransformer type of starter would have to be selected.

With a primary-resistor or primary-reactor starter, line current is the same as motor current and thus varies directly with motor terminal voltage. Also, power taken from the line is much higher than required by the autotransformer starter. Therefore, the autotransformer type is the most efficient.

In an autotransformer circuit, motor current also varies directly with impressed voltage. However, because of the transformer action, line current varies as the square of the motor terminal voltage, plus transformer magnetizing current. This transformer excitation current is approximately 25 per cent of

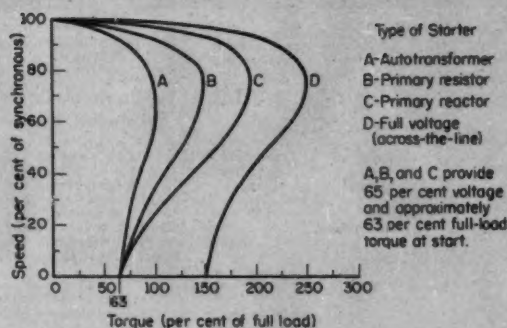


Fig. 3—Comparison of speed-torque characteristics for starting a typical squirrel-cage motor with reduced-voltage and across-the-line starters.

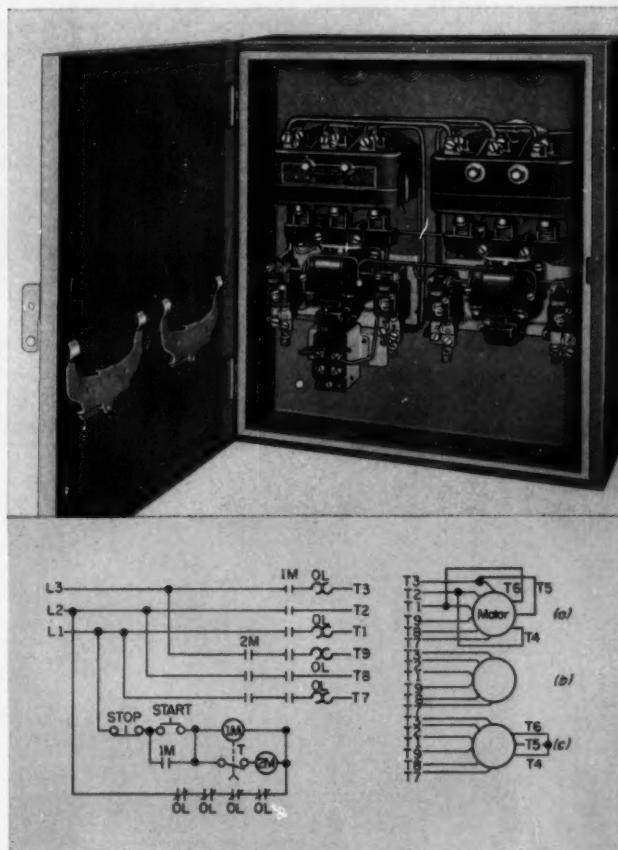


Fig. 4—Typical part-winding starter and basic circuit application for a, nine-lead delta, b, six-lead delta or wye, and c, nine-lead wye squirrel-cage motor connections.

Table 1—Squirrel-Cage Motor Starting Characteristics Produced by Reduced-Voltage Starters

Type of Starter	Term. Volt.* (% of line voltage)	Line Current* (% of locked-rotor current)	Torque* (% of locked-rotor torque)	Remarks
Auto-transformer	65	47 approx. Varies as square of motor terminal voltage plus transformer magnetizing current.	42 Varies as square of motor terminal voltage.	Starting losses low. Open transition. (Korndorfer circuit has closed transition.) Low max starting torque.
Primary resistor	65	85 Varies directly with motor terminal voltage.	42	Starting losses high. Closed transition. High max starting torque.
Primary reactor	65	65 Varies directly with motor terminal voltage.	42	Starting losses medium. Closed transition. Highest max starting torque.

*Numerical values apply at standstill only.

the full-load current. The relationship is

$$I_t = V_a^2 I_{LR} + I_m \quad (1)$$

where I_t = autotransformer starting line current, amp; V_a = motor terminal voltage, per cent of line voltage; I_{LR} = locked-rotor current, amp; I_m = transformer magnetizing current, amp.

EXAMPLE: A 100-amp motor is connected to the 65 per cent tap in an autotransformer starter. Locked-rotor current is 6 times full-load current. Find the starting line current.

$$I_t = (0.65)^2 (6) (100) + 0.25 (100)$$

$$= 0.42 (600) + 25 = 277 \text{ amp}$$

Further comparisons of reduced-voltage starters are given in Fig. 3 and Table 1.

Part-Winding Starters

Increment starting can also be provided by part-winding motors, although the method does not involve reducing voltage at the motor terminals. Therefore, part-winding starting is not technically a reduced-voltage method but is generally included because of similarities in the control systems and in

the advantages that are obtained with this method.

A part-winding motor has two separate, parallel windings. A part-winding starter consists of two ordinary starters, each selected for one-half the horsepower rating of the motor, and a time-delay relay, Fig. 4. In the diagram, pressing the start button connects one winding to the power supply. After the preset time delay, the second winding is also connected to the line.

Full voltage is applied directly to each motor winding, but starting current and torque are substantially reduced by the motor design. This method of limiting starting current costs less than any of the reduced-voltage techniques.

Part-winding starting is often favored when special power company regulations must be met. Although total available power may be large, momentary current limitations, usually specified in amperes for durations of 1 or 2 seconds, are imposed on the user to prevent excessive voltage disturbances.

A speed-torque curve is shown in Fig. 5 for a typical part-winding motor. The main drawback of the part-winding starter is that torque may dip substantially during acceleration. Consequently, the motor may not fully accelerate a load on the first winding. Then, when the second winding is connected, it draws a large inrush current from the line and defeats the purpose of increment starting.

Thus, part-winding starting is used to provide reduced increments of starting torque for particular machines or equipment and to meet power company limitations. Typical applications include refrigeration systems, irrigation pumps, air conditioners, and conveyor systems.

Next article in this series will cover multispeed squirrel-cage motors and their control.

REFERENCES

This article is the third in a series by J. Ronald Wickey and Arthur S. Newman Jr. on ac motor control. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. Squirrel-Cage Motors December 22, 1960
2. Across-the-Line Starting January 5, 1961

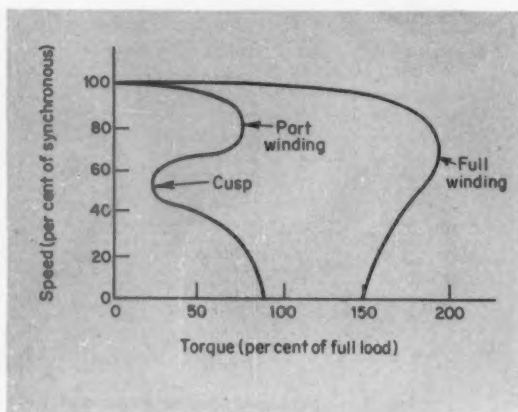
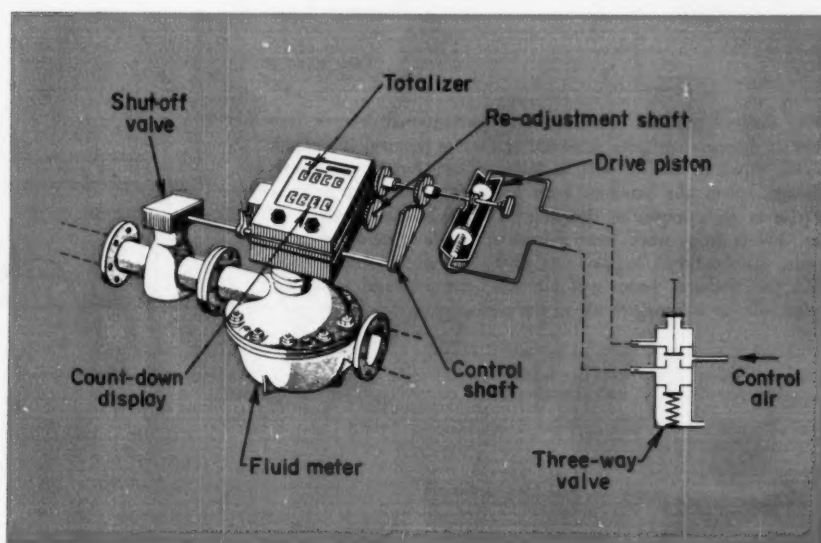


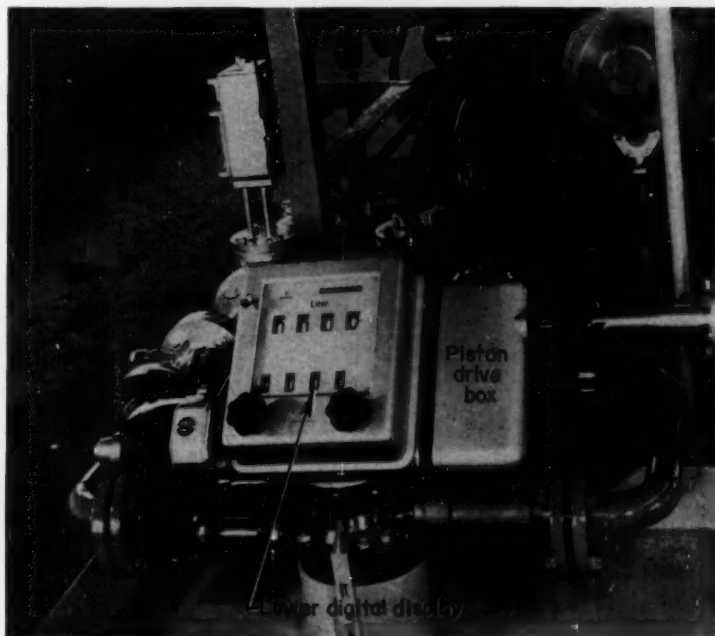
Fig. 5—Speed-torque curves for typical squirrel-cage motor with full and part-winding connections.

Air Pulse Meters Fluid Flow

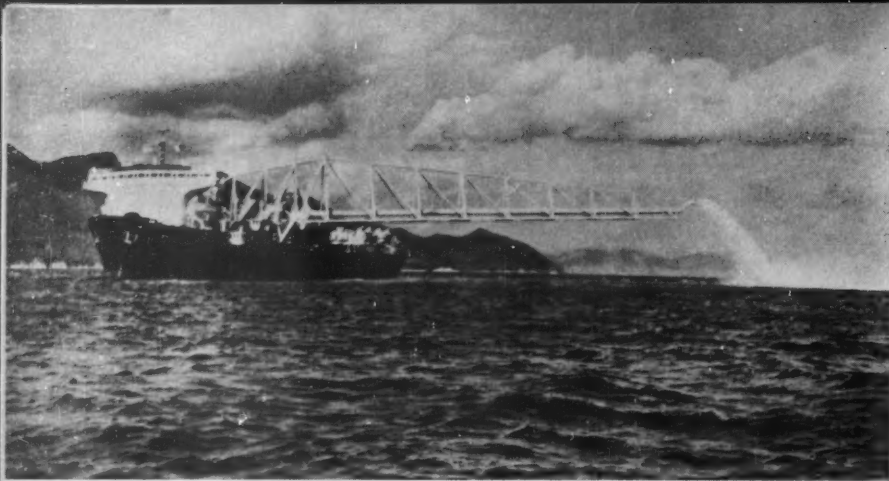
METERED QUANTITIES of fluid are transmitted through a pipeline by a valve and counter system that responds to a pneumatic demand signal. Quantity to be metered on each signal is set by control knobs on the digital display box. Lower display, indicating quantity set, counts down to zero and trips the shutoff valve. Upper display keeps a running total of fluid transmitted. For more precise control, valve mechanism goes through a throttling step just before shutoff is actuated.



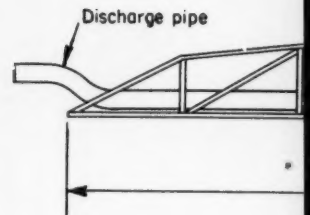
RACK ON SHAFT of drive piston rotates valve to open position on pulse from spring-loaded three-way valve. Metering unit holds valve open when the piston returns to set position. Count-down mechanism is driven by a positive-displacement fluid-metering device in the fluid stream. After shutoff, a pneumatic-servo system restores the lower counter to its preset figure.



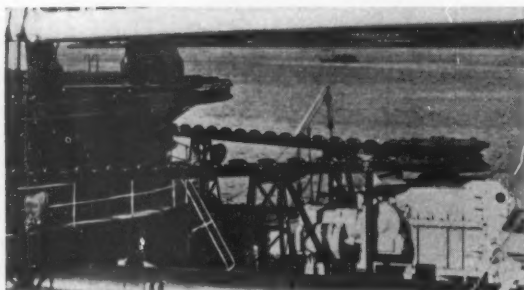
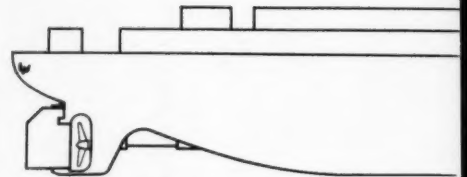
COUNT-DOWN fluid meter is a development of Siemens & Halske AG, Munich, Germany.



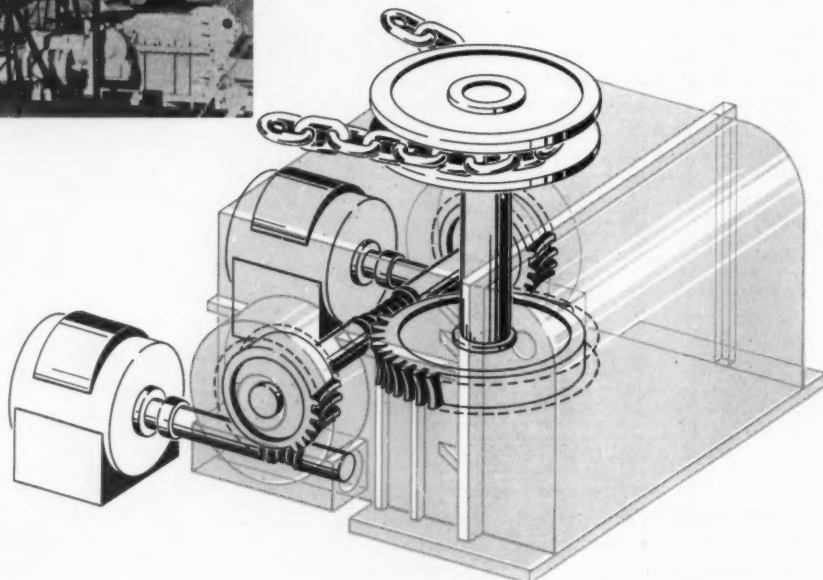
Big Weight



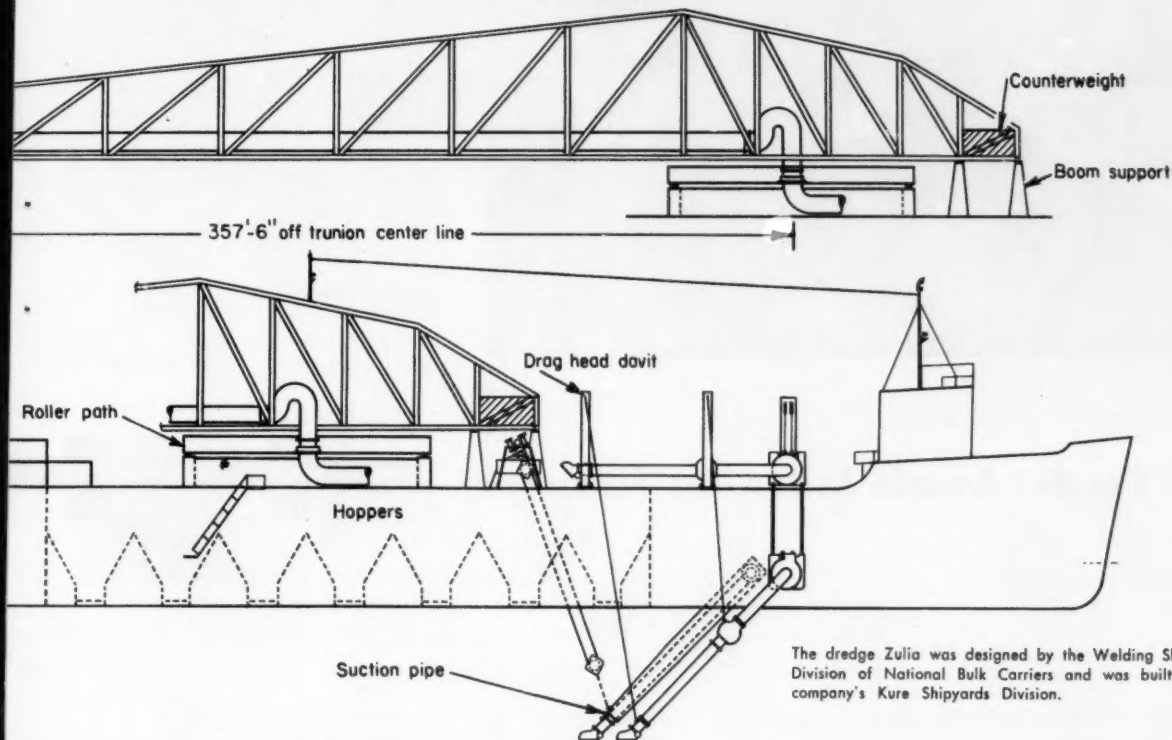
CARRYING AWAY dredged material is waste time. Conventional dredges have either stored slurry in hoppers for later removal, or they've pumped it through a pontoon-supported pipeline. This limits mobility. The "Zulia," a gigantic new Liberian dredge, solves the problem with a 415-ft boom that holds a 57-in. discharge pipe at right angles to the ship. The rig allows discharge of debris more than 400 ft from work location—more than sufficient for most dredging operations. Conventional hoppers are available on the ship for use in locations where the discharge boom will not solve the problem. A 992-ton counterweight helps balance 260 tons of silt in the pipe.



TURNTABLE for Zulia's boom, mounted on an 80-ft roller bearing, is chain driven from a pair of 150-hp motors through a double-cone drive provided by Cone-Drive Gears, Detroit.



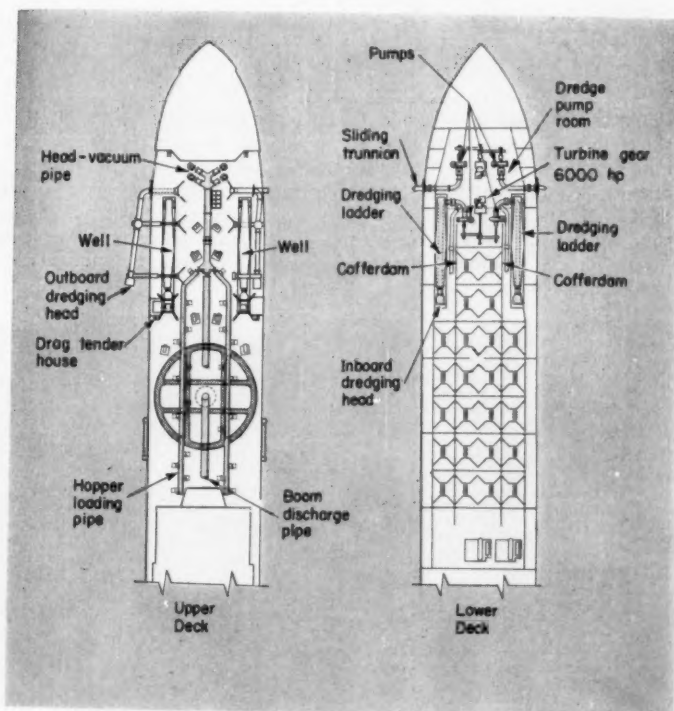
Balances Zulia Boom

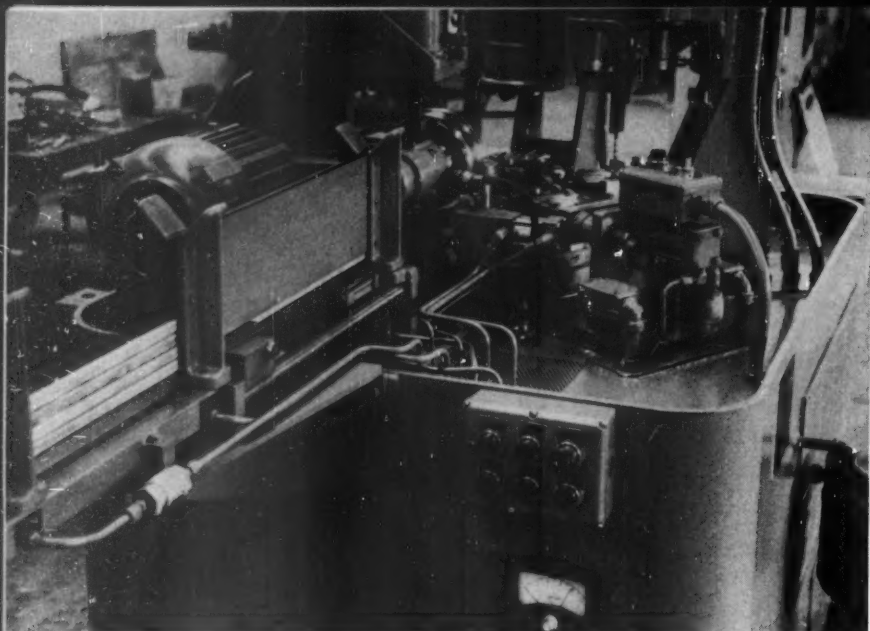


The dredge Zulia was designed by the Welding Shipyards Division of National Bulk Carriers and was built in the company's Kure Shipyards Division.

INBOARD DREDGING HEADS

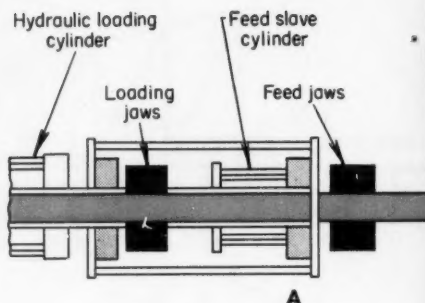
work through wells in the ship decking. Sliding trunnions allow the heads to operate at depths up to 60 ft and still maintain the approximate 45-degree working angle at which they are most efficient. Each of the heads cuts a 6-ft wide trench. The vacuum is drawn through a 32-in. diam pipe. The four slurry pumps are connected to a 57-in. manifold from which slurry may be directed to the boom discharge pipe or to two 45-in. hopper loading pipes. Pumps are driven by two sets of turbines through double-reduction gearing. Each turbine set can develop 6000 shaft hp.





Bar fed terminal collar machine was developed for Westinghouse by Automation Development Corp., Mentor, Ohio.

Bar Feeder Loads Indexing Fixtures

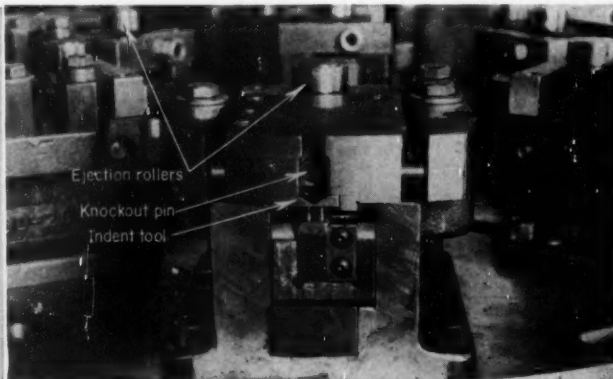
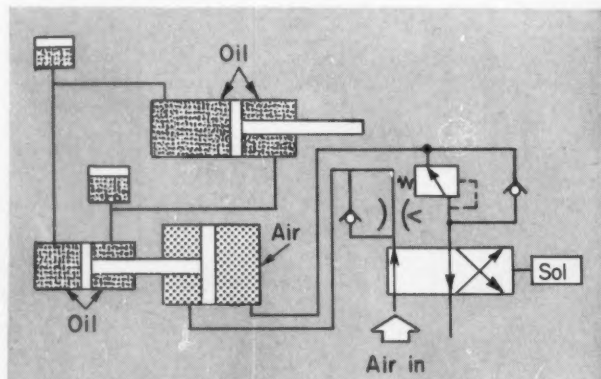


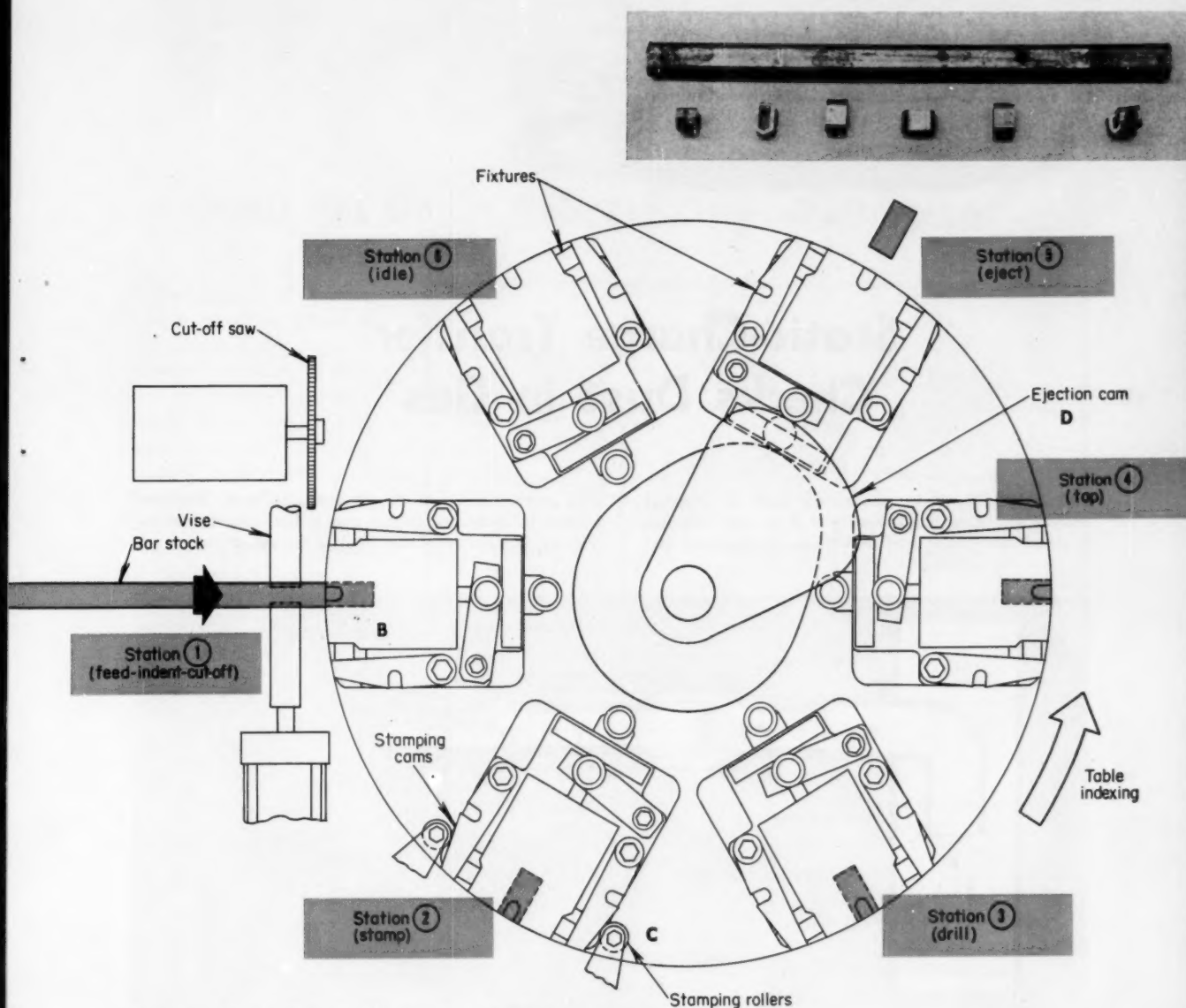
ELIMINATING VIBRATORY FEEDERS and blank-orienting devices, a bar-stock feeder simplifies the design of a merry-go-round terminal-collar machine. A hydraulic loader presses the bar stock through jaws of a vise and into a fixture.

After workpiece is cut off, subsequent fixtures arriving at station 1 are loaded by an incremental bar feed—also hydraulically powered—until the bar is used up. A limit switch then brings the loader into play again.

DETAIL A: Hydraulic drive for the feeder is actually a slave unit run by the machine's pneumatic system. Here's how it works: A combination air-oil cylinder operates by air pressure. Slave cylinder is connected to the oil side of this cylinder in a closed hydraulic circuit. Difference in areas between slave-cylinder and master-cylinder pistons provides increased pressure needed for the feed stroke.

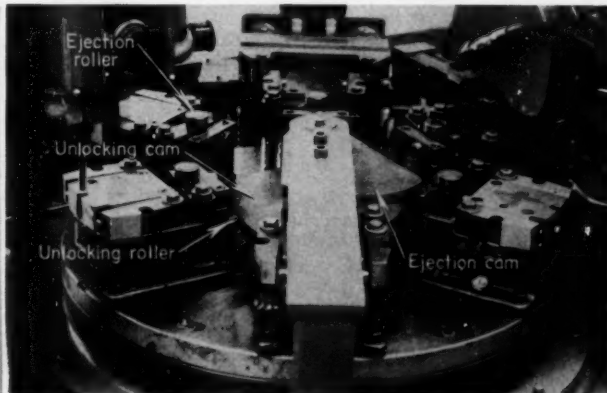
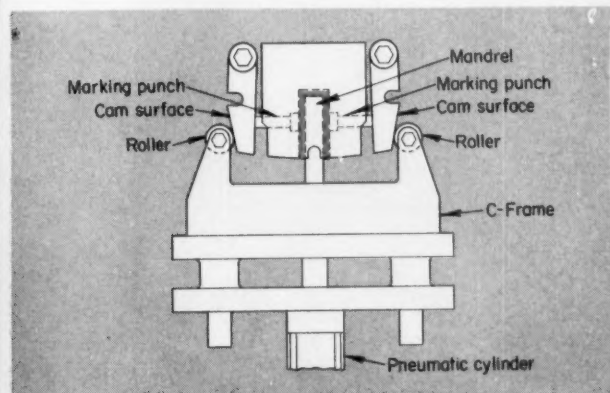
DETAIL B: Extra power in feeder is needed to operate a cam slide and close indent tools that do double duty as holding jaws during following operations. Bar is inserted under spring pressure. When it bottoms on a stop, the spring closes as the bar feeder continues to move forward, driving in a wedge to lock the indent tools and clamp the workpiece.



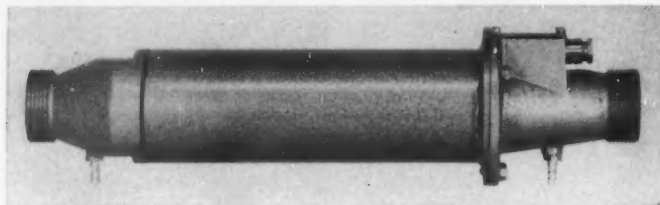


DETAIL C: Cam rollers operate on cam surfaces to close the stamping punches (station 2). Company name, trademark and identifying symbols are stamped on the workpiece with a caliper motion. Radial motion of the C-frame also inserts a mandrel to support the piece against the stroke of the die.

DETAIL D: Release and ejection are accomplished by cams operated from the center of the table outward. As the fixtures move past, cams strike rollers which release indent tools and actuate knockout pin.



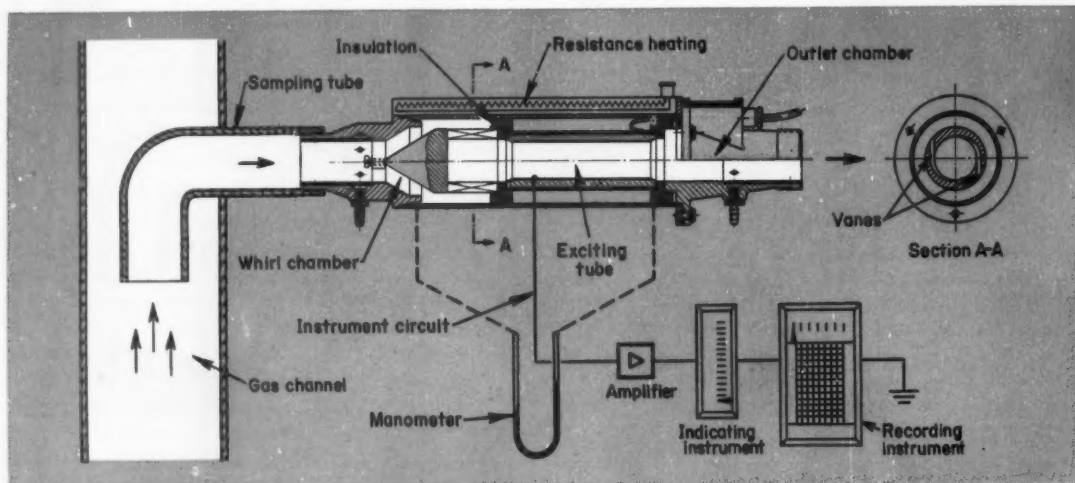
Electrostatic gas sampler is a product of J. C. Eckardt AG, Cannstatt, Germany.



Static-Charge Transfer Checks Dust in Gas

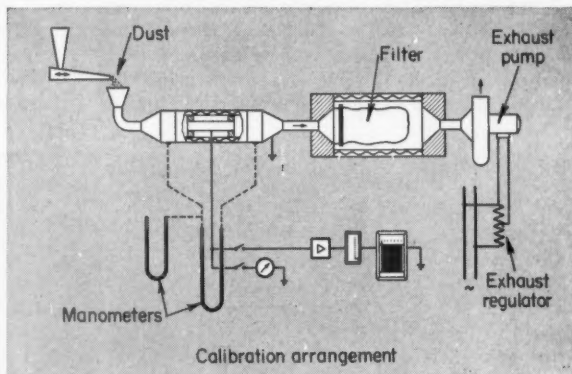
GAS SAMPLER checks contaminant level in stream by whirling gas against the charged wall of the unit. Exchange of electrostatic charge between wall and contaminant parti-

cles produces a measurable electromotive force. Resulting current in readout equipment gives a fair instantaneous indication of the contaminant level in the gas stream.



INSTRUMENT CIRCUIT is closed by particles of contaminating material that pick up charge from exciting tube and deposit it on the walls of the grounded outlet chamber. The more contaminant in the gas, the more current flows in the instrument circuit. Vanes in the whirl chamber, section A-A, give the gas a turbulent rotary motion before it enters the exciting tube. Resistance heating element keeps moisture from condensing in the tube.

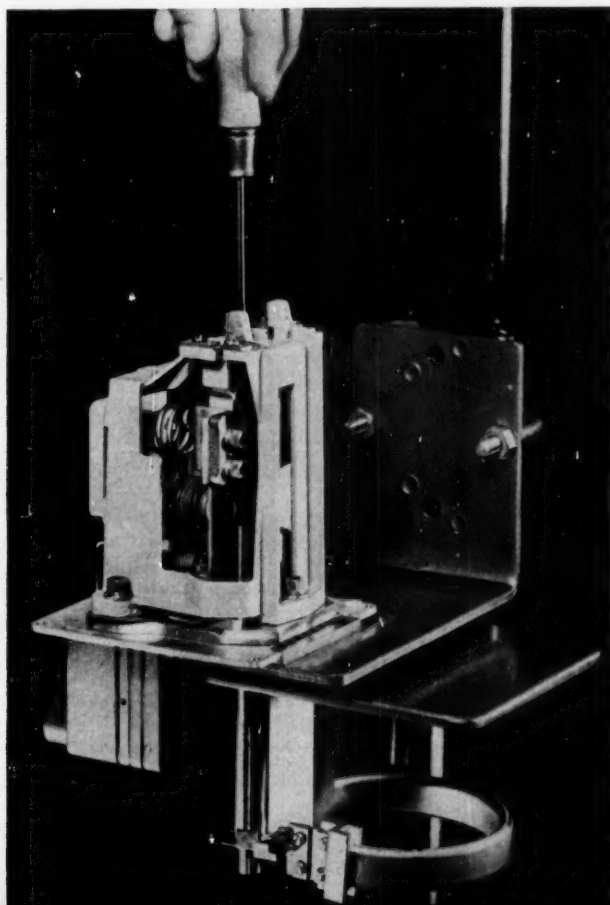
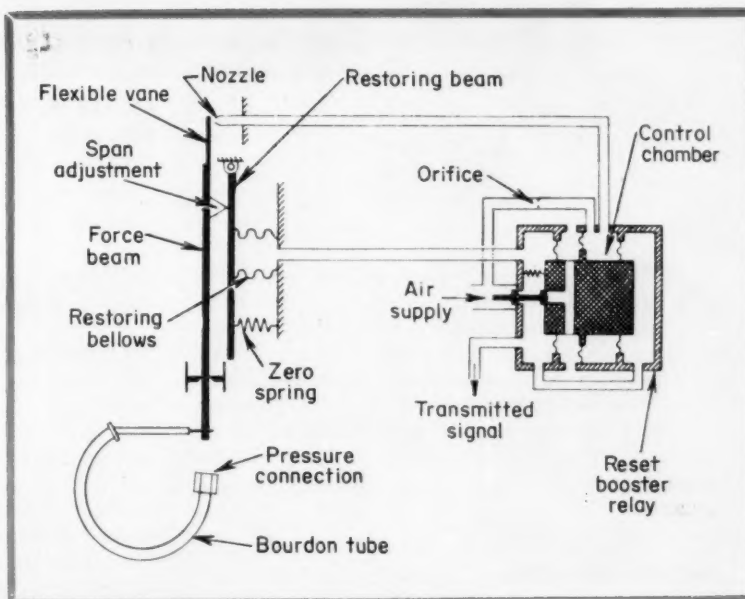
CALIBRATING SETUP uses exhaust fan to simulate flow of gas. Typical contaminant dust is sifted into the air flow. After a trial run during which manometers calibrate air flow, dust in the filter is weighed and relationship to gas (air) flow and integrated current from chart is established. With this parameter recorded, instantaneous readings of contaminant level can be taken from the indicating instrument, or totaled records over a period



can be produced on stripchart. Calibration is necessary because contaminant particles in various processes may vary widely in conductivity, size, and weight.

Air Jet Gages Bourdon-Tube Deflection

DEFLECTION of a Bourdon tube is sensed by change of air pressure in a nozzle. As pressure changes in the Bourdon tube, a flexible vane is moved toward or away from an air-jet nozzle. This affects pressure in the control chamber of the reset booster relay, opening either the inlet valve (increase in control pressure) or the exhaust valve (decrease in control pressure). Restoring pressure is transmitted as a signal.



TRANSMITTER IS EQUIPPED with a span-adjustment fulcrum and a zero spring. For accuracy, the normal available span of reading can be suppressed—that is, the whole range of available air-pressure signal can be made to measure only one-tenth of the rated pressure span—by moving the span adjustment. A lead screw turned by a screwdriver accomplishes this. When the limited span has been established, it may be shifted anywhere along the available range by means of the zero spring. For example: Suppose a transmitter with a range of 1000 psi is required to measure a span of only 100 psi. Indication of the 100 psi variation could be expanded to cover the whole air pressure "scale" by moving the span adjustment. But if the requirement is to measure 100 psi from 450 psig to 550 psig instead of from 0 to 100 psig, this adjustment could be made with the zero spring. Bourdon-tube force balance pressure transmitter was developed by the Bailey Meter Co., Cleveland.

Surface Hardening of Steels

Part 1—Hardening Methods

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SURFACE hardening gives a dual personality to a steel part. The surface or case is hard, to resist wear; the core is soft, to facilitate machining, or tough, to resist shock. This article, first of a two-part series, considers two general classifications of surface-hardening procedures: 1. Those that involve a chemical reaction between the surface of the steel and an external medium. 2. Those that develop surface hardness by selective heating and quenching.

Surface Absorption

Hardening processes in the surface-absorption group consist of two definite stages: 1. Impregnation of the surface of the steel with sufficient carbon, nitrogen, or both, to impart greater hardenability.

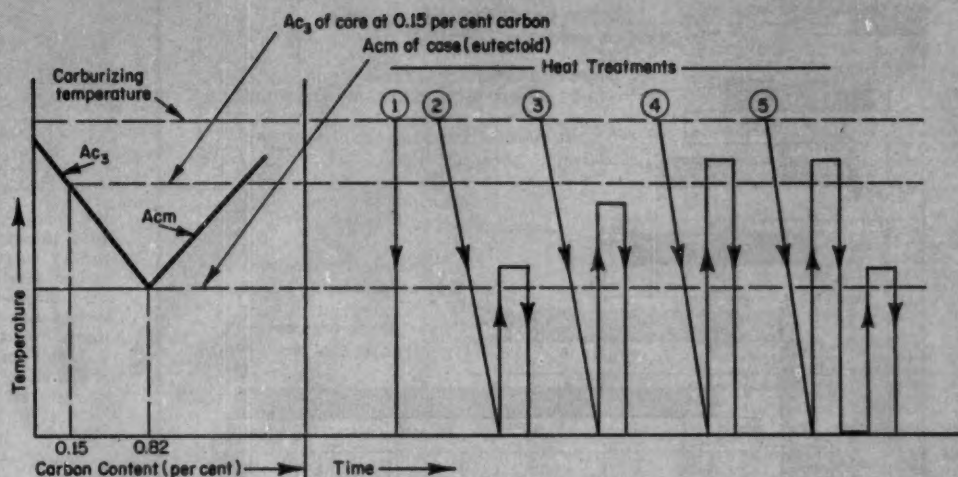
2. Thermal treatment to achieve the desired properties in both case and core of the material.

Carburizing: ASTM defines carburizing as: "A process of case hardening in which carbon is introduced into a solid iron-base alloy by heating above the transformation-temperature range while in contact with a carbonaceous material which may be a solid, liquid, or gas." Both solid and gas-carburizing methods produce a high carbon concentration on the surface of the steel part during the initial or absorption phase. The carbon migrates toward the interior of the part during the second phase by diffusion. Depth of case is a function of time and temperature of carburization, Table 1.¹

*Now with Lewis Research Center, NASA, Cleveland, Ohio.
¹References are tabulated at end of article.

Table 1—Time and Temperature Effects on Case Depth

Time (hr)					Temperature (F)					
	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850
					Case Depth (in.)					
1	0.008	0.010	0.012	0.015	0.018	0.021	0.025	0.029	0.034	0.040
2	0.011	0.014	0.017	0.021	0.025	0.030	0.035	0.041	0.048	0.056
3	0.014	0.017	0.021	0.025	0.031	0.037	0.043	0.051	0.059	0.069
4	0.016	0.020	0.024	0.029	0.035	0.042	0.050	0.059	0.069	0.079
5	0.018	0.022	0.027	0.033	0.040	0.047	0.056	0.066	0.077	0.089
6	0.019	0.024	0.030	0.036	0.043	0.052	0.061	0.072	0.084	0.097
7	0.021	0.026	0.032	0.039	0.047	0.056	0.066	0.078	0.091	0.105
8	0.022	0.028	0.034	0.041	0.050	0.060	0.071	0.083	0.097	0.112
9	0.024	0.029	0.036	0.044	0.053	0.063	0.075	0.088	0.103	0.119
10	0.025	0.031	0.038	0.046	0.056	0.067	0.079	0.093	0.108	0.126
11	0.026	0.033	0.040	0.048	0.059	0.070	0.083	0.097	0.113	0.132
12	0.027	0.034	0.042	0.051	0.061	0.073	0.087	0.102	0.119	0.138
13	0.028	0.035	0.043	0.053	0.064	0.076	0.090	0.106	0.123	0.143
14	0.029	0.037	0.045	0.055	0.066	0.079	0.094	0.110	0.128	0.149
15	0.031	0.039	0.047	0.057	0.068	0.082	0.097	0.114	0.133	0.154
16	0.032	0.039	0.048	0.059	0.071	0.084	0.100	0.117	0.137	0.159
17	0.033	0.040	0.050	0.060	0.073	0.087	0.103	0.121	0.141	0.164
18	0.033	0.042	0.051	0.062	0.075	0.090	0.106	0.125	0.145	0.169
19	0.034	0.043	0.053	0.064	0.077	0.092	0.109	0.128	0.149	0.173
20	0.035	0.044	0.054	0.066	0.079	0.094	0.112	0.131	0.153	0.178
21	0.036	0.045	0.055	0.067	0.081	0.097	0.114	0.134	0.157	0.182
22	0.037	0.046	0.056	0.069	0.083	0.099	0.117	0.138	0.161	0.186
23	0.038	0.047	0.058	0.070	0.085	0.101	0.120	0.141	0.164	0.190
24	0.039	0.048	0.059	0.072	0.086	0.103	0.122	0.144	0.168	0.195
25	0.039	0.049	0.060	0.073	0.088	0.106	0.125	0.147	0.171	0.199
26	0.040	0.050	0.061	0.075	0.090	0.108	0.127	0.150	0.175	0.203
27	0.041	0.051	0.063	0.076	0.092	0.110	0.130	0.153	0.178	0.206
28	0.042	0.052	0.064	0.078	0.094	0.112	0.132	0.155	0.181	0.210
29	0.042	0.053	0.065	0.079	0.095	0.114	0.134	0.158	0.185	0.214
30	0.043	0.054	0.066	0.080	0.097	0.116	0.137	0.161	0.188	0.217



Treatment Number	Remarks
1	Most economical treatment since it consists of a direct quench from the carburizing temperature. Used with fine-grained steels for such parts as automotive gears where a high-carbon case (1.10 to 1.40 per cent) is required. Case is highly fatigue resistant because some austenite is retained.
2	Usually called "case-refinement" cycle. In steels with under 0.90 per cent carbon case content, this treatment achieves excellent wear resistance while retaining a readily machined core. If a higher carbon concentration is present, however, the case can become brittle.
3	A modified case-refinement cycle. Case becomes slightly coarsened. Core is partially refined. Like Treatment No. 2, not recommended for cases having over 0.90 per cent carbon.
4	For applications requiring maximum core strength and hardness. Retention of austenite within the case of a highly alloyed steel, however, results in a slightly lower case hardness.
5	Recommended for coarse-grained steels for best combination of wear resistance, toughness, and impact resistance.

Fig. 1—Post-carburization heat treatment. A_{c3} is the upper critical temperature of core; A_{c1} is the upper critical temperature of case.

Pack Carburization: The pack method is the oldest and is considered the most foolproof of the carburizing processes. Parts that are to be surface treated are packed with a solid carburizing material in a closed container. The carburizing action occurs during the heating cycle. The carburizing medium is a mixture of hardwood charcoal, coke, and a carbonate energizer that increases the reaction rate.

The pack-carburizing method is used to obtain medium to heavy (0.040 to 0.060 in.) case depths. Warping of parts is nominal because: 1. The packing material serves as a supporting medium during the carburizing cycle. 2. Natural, slow cooling in the container—the usual practice when reheat operations are to follow—reduces the thermal gradient within the part.

Principal disadvantages of pack carburization are: 1. Heating and cooling cycles are long. 2. Maximum carbon content of the case, depth of case, and uniformity of case characteristics are difficult to control. For these reasons, the minimum recommended case depth for pack carburization is about 0.040 in.

Pack carburizing is invariably followed by one of several heat-treatment methods, Fig. 1.² Because carburization lowers the critical temperature of the case, reheat temperatures, to obtain a desired work hardness, must be specified accordingly. Typical mechanical properties of several common alloy carburizing steels after various heat treatments are given in Table 2.³

Gas Carburization: Fuels used for gas carburization are propane, butane, or natural gas. A diluent such as air, flue gas, or charcoal gas is usually added to the hydrocarbon gas to minimize soot deposits which can cause spotty carburization.

Compared to the pack method, gas-carburization costs are lower since the parts are put directly into the furnace. This process is particularly adaptable for carburizing small parts that can be tumbled in a rotary-hearth furnace. Another advantage is that the temperature of carburizing may be lowered at the end of a cycle to permit direct liquid quenching of the parts. However, where case depth is heavy, a reheat operation is usually necessary.

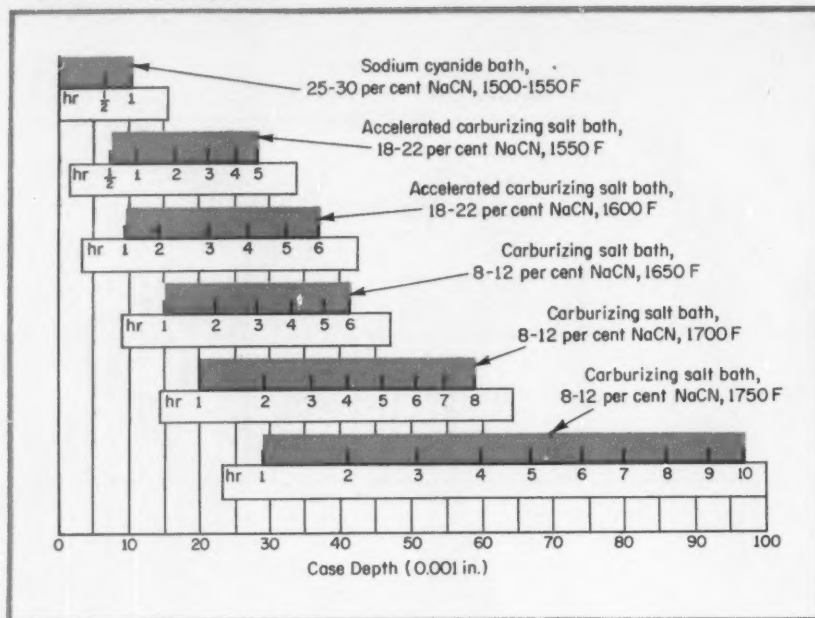
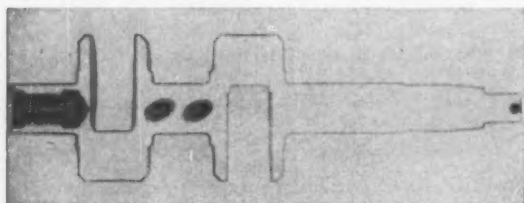
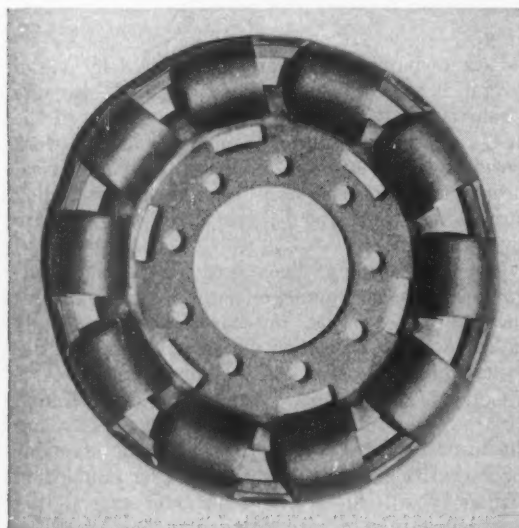


Fig. 2 — Average times and case-depths (color bands) to 0.30 per cent carbon level for various chemical-reaction types of surface-hardness treatments. Chart, courtesy E. I. du Pont de Nemours & Co. Inc.



Macroetched section shows carburized case 0.045 to 0.060 in. deep produced on SAE 4615 steel engine crankshaft. Photo, courtesy Ajax Electric Co.



Thin carbonitrided case of 0.005 in. produces file-hard surface on SAE 1010 clutch outer retaining plate. Distortion is held to 0.001 in. maximum.

The gas-carburization method is principally used for case depths up to 0.040 in. However, greater depth may be obtained by increasing the time or temperature of carburizing or by varying the gas composition. Part surfaces are relatively free from scale when directly quenched and, because a low quenching temperature is normally employed, distortion is minimized. However, if a reheat is necessary, scaling of parts will result unless a protective atmosphere is used during the operation.

Cyaniding: The sodium-cyanide-bath method carburizes at relatively low temperatures (1500 to 1550 F) where large amounts of nitrogen are absorbed. The nitrogen serves as a barrier to carbon absorption and resulting cases are limited to about 0.010 to 0.015 in.

Liquid Carburization: A modified form of cyaniding—liquid carburization—uses activators and catalysts with cyanide salts. These baths, which may be operated up to about 1750 F, suppress nitrogen absorption and favor carbon penetration, thus permitting heavier case depths, Fig. 2.

Advantages of the cyaniding and liquid-carburizing methods include: 1. Surfaces of parts are protected during immersion in the liquid salt. 2. The crust of salt that forms around cold parts as they enter the bath serves as an insulator against thermal shock. 3. Heat transfer from the liquid medium is rapid. 4. Heating is uniform. 5. Distortion and quench cracking are minimized.

Carbonitriding: Like cyaniding, the carbonitriding process produces a simultaneous absorption of carbon and nitrogen. The transfer medium for carbonitriding, however, is a carburizing atmosphere that contains ammonia gas. The process is practical up to about 1700 F. Parts are subsequently cooled rapidly to produce the desired mechanical properties.

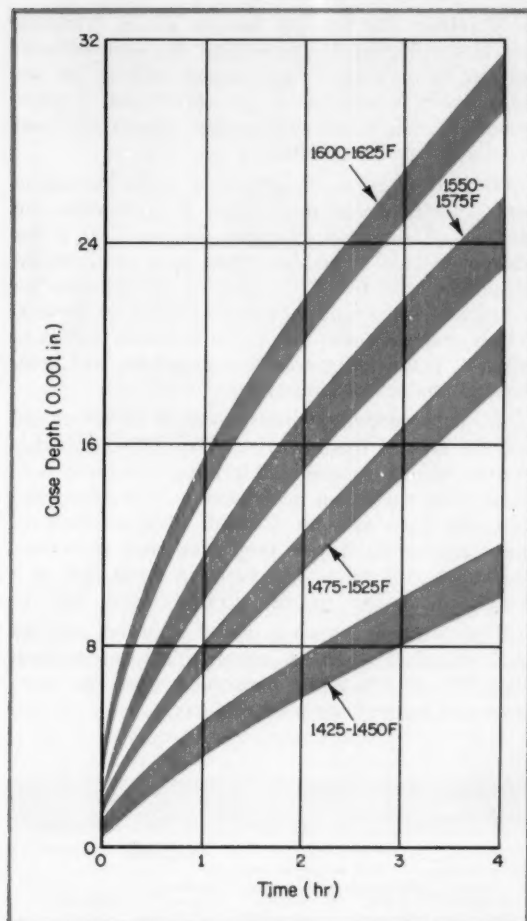


Fig. 3—Influence of time and temperature on case depths of carbonitrided parts.

Carbonitriding is similar to carburizing in that the mechanism of hardening is a transformation of austenite to martensite. The major difference between the two processes is that the carbonitrided case contains an appreciable amount of nitrogen in addition to carbon. The austenite produced can be considered as an alloy austenite—the nitrogen being the alloying element. Since the relatively stable austenite is produced, the process can be conducted at low temperatures—about 1425 F—and parts can be quenched directly.

The high hardenability of a carbonitrided case usually permits the use of an oil quench, thus keeping quench cracking and distortion to a minimum. The hardenability produced frequently allows parts to be made from a carbon steel rather than an alloy.

Because of the relatively high nitrogen content of the case, hardness is not appreciably affected by tempering temperatures of 600 to 800 F. The same high nitrogen content, however, limits the depth of hardened case of carbonitrided parts, Fig. 3.⁴

In such applications as bushings, ball-bearing spacers, and washers, where only case properties are important, carbonitrided parts are used without tempering. Where core properties require improve-

Surface-Hardening Procedures

Case Depth (in.)	Hardness, Rockwell C*	Remarks and Applications
Carburizing		
To 0.020	S 60+ C 18+	Light case depths used for high wear resistance and low loads. Typical applications are push-rod balls and sockets, shifter forks, small gears, and water-pump shafts.
0.020-0.040	S 60+ C 18+	Moderate case depths used for high wear resistance and moderate to heavy service loads. Applications include steering-arm bushings, valve rocker arms and shafts, gears, and brake-pedal shafts.
0.040-0.060	S 60+ C 18+	Heavy case depths used for high wear resistance to sliding, rolling, or abrasive action, and for high resistance to crushing or bending loads. Applications include ring gears, transmission and slide gears, piston pins, gear shafts, roller bearings, and kingpins.
0.060+	S 60+ C 18+	Extra heavy case for maximum wear and shock resistance. Typical applications are camshafts, armor plate, and cam surfaces.
Carbonitriding		
0.003-0.020	S 62-65 C 32-35	Produces a hard, wear-resistant, clean surface. Used on thin-wall tubing, ratchet wrenches, bolts, screws, small gears, and pneumatic cylinders.
Nitriding		
To 0.030	...	Cycle of 50 hr produces 0.015-in. case, where initial 0.006 in. has Vickers hardness over 900. Cycle of 100 hr produces 0.030-in. case where initial 0.011 in. has 900+ Vickers hardness. Applications include aircraft exhaust valves, instrument shafts, pump shafts, and steam valves.
Flame Hardening		
0.030-0.125	S 37-55 C 20+	Produces high surface hardness with unaffected core. Surface is relatively free from scaling and pitting. Used on sprocket and gear teeth, track rails, and lathe beds and centers.
Induction Hardening		
0.030-0.125	S 60+	Produces high surface hardness with ductile core. Parts have good fatigue resistance. Applications include camshafts, sprocket and gear teeth, rocker-arm shafts, mower and shear blades, lathe beds, and bearing surfaces of axle shafts and crankshafts.

* S=surface; C=core.

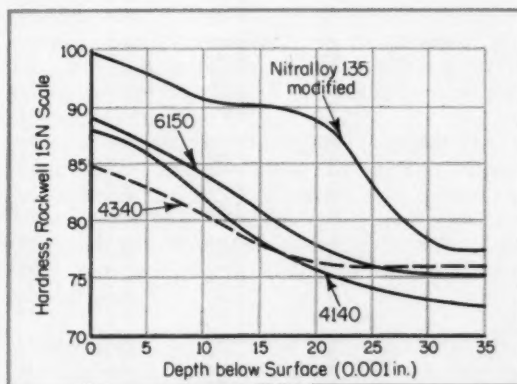
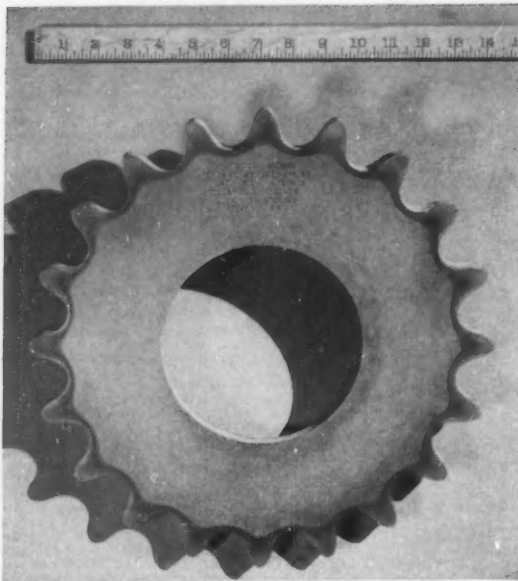


Fig. 4—Depth-of-hardness comparison of nitralloy 135 modified steel and standard AISI steels.

ment, such as in gears, shafts, or screws, a tempering operation of 1 to 2 hr at 300 to 1000 F is usually specified—the higher temperatures normally being used for cases containing high amounts of nitrogen.



Tocco induction-hardened sprocket showing uniform case depth and case pattern. Tooth hardness of 55 Rockwell C was produced by 90 kw of power at 9600 cps with cycle of 75 sec heat, 10 sec delay, and 10 sec quench. Photo, courtesy Ohio Crankshaft Co.

Nitriding: For certain ferrous alloys, nitriding provides a hardened case without the need for subsequent quenching. Parts are heated in an atmosphere of ammonia—or in contact with a nitrogenous material—and surface hardening is produced by the absorption of nitrogen.

Nitrided cases on nitralloy-type steels have good wear resistance and retain their high hardness up to 1000 F for long exposures—or to 1200 F for shorter periods. Nitrided steels have excellent fatigue life, resistance to seizing or galling, and resistance to stress concentration at notches or threads. These materials also resist the corrosive action of alkalis, petroleum products, atmosphere, and combustion products of natural gas.

Although nitralloy steels have been developed for this type of treatment, standard AISI steels that contain elements capable of forming nitrides such as aluminum, chromium, molybdenum, vanadium, and tungsten may also be nitrided. Improvement of wear resistance, fatigue properties, and endurance limits are realized in the standard steels, but to a lesser extent than in the nitralloy steels, Fig. 4.⁵

The nitriding process is one of diffusion, and the cycle required to obtain appreciable case depths is long, Fig. 5.⁶ Processing temperatures are low, however, and parts do not warp or distort.

Table 2—Properties of Common Alloy Steels After Carburizing and Heat Treating

AISI Type	Treatment*	Case Properties		Core Properties					
		Depth (in.)	Hardness, Rockwell C	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Elongation in 2 in. (per cent)	Reduction in Area (per cent)	Impact, Izod (ft-lb)	Hardness (Bhn)
E3310	A	0.047	59.5	182	149	15.3	57.4	40.0	375
	B	0.047	54.5	181	153	15.0	58.2	40.0	375
	C	0.047	61.0	180	146	14.3	57.3	55.0	363
	D	0.047	57.5	180	150	14.5	57.8	57.0	363
	E	0.047	61.0	177	144	15.3	58.5	47.0	352
	F	0.047	58.0	176	146	14.8	58.9	50.0	341
4320	A	0.060	60.5	217	160	13.0	50.1	32.5	429
	B	0.060	58.5	216	159	12.5	49.4	26.0	415
	C	0.075	62.5	218	178	13.5	48.2	27.5	429
	D	0.075	59.0	212	173	12.5	50.9	28.8	415
	E	0.075	62.0	152	97	19.5	49.4	49.3	302
	F	0.075	59.0	146	95	21.8	56.3	48.5	293
4620	A	0.075	60.5	148	117	17.0	55.7	46.5	311
	B	0.060	58.5	148	116	16.8	57.9	42.5	302
	C	0.075	62.5	119	84	19.5	59.4	52.0	277
	D	0.065	59.0	116	81	20.5	63.6	69.0	248
	E	0.060	62.0	122	77	22.0	55.7	64.0	248
	F	0.060	59.0	115	77	22.5	62.1	78.3	235
4820	A	0.039	60.0	205	166	13.3	53.3	33.0	415
	B	0.039	56.0	201	179	12.8	53.0	30.0	401
	C	0.047	61.0	208	167	13.8	52.2	44.0	415
	D	0.047	57.5	205	185	13.0	53.3	47.0	415
	E	0.047	60.0	205	168	13.8	52.4	31.0	415
	F	0.047	56.5	197	172	13.0	53.4	29.0	401
8620	A	0.056	63.0	192	150	12.5	49.4	27.5	388
	B	0.050	58.0	181	134	12.8	50.6	34.3	352
	C	0.075	64.0	189	150	11.5	51.6	26.3	388
	D	0.076	61.0	168	121	14.3	53.2	29.5	341
	E	0.070	64.0	133	83	20.0	56.8	55.8	269
	F	0.070	61.0	130	77	22.5	51.7	66.3	262
9310	A	0.039	59.5	180	144	15.3	59.1	57.0	375
	B	0.039	54.5	178	147	15.0	59.7	46.0	363
	C	0.047	62.0	173	135	15.5	60.0	61.0	363
	D	0.047	59.5	168	138	15.5	60.0	39.0	341
	E	0.055	60.5	175	139	15.3	62.1	54.0	363
	F	0.055	58.0	170	138	14.8	61.8	63.0	352

*All steels carburized at 1700 F. Subsequent heat treatment consisted of:

A. Direct quench in agitated oil, temper at 300 F.

B. Direct quench in agitated oil, temper at 450 F.

C. Slow cool from carburizing temperature, reheat to 1400-1500 F, quench in agitated oil, temper at 300 F.

D. Same as Treatment C, except final temper is at 450 F.

E. Slow cool from carburizing temperature, reheat to 1425-1475 F, quench, second reheat to 1500-1550 F, quench.

temper at 300 F.

F. Same as Treatment E, except final temper is at 450 F.

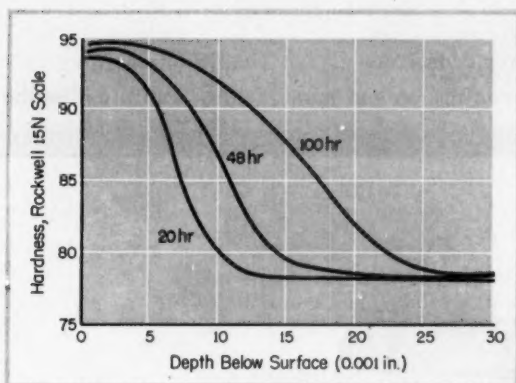


Fig. 5—Typical depth-hardness characteristics of nitralloy 135 modified steel, nitrided at 975 F with 30 per cent ammonia dissociation.

The nitriding process is relatively expensive both because of the long process cycle and because pre-treatment of parts is necessary to obtain a surface structure for maximum property response and a core with adequate strength. Nitrided parts "grow" slightly during processing. The extent of growth is best determined by processing pilot parts. Production parts are then made undersize to compensate for this growth factor.

Selective Heating

Induction and flame-hardening procedures require special equipment to obtain the necessary heat input to the parts. The heating phase consists of raising the surface to above the upper critical temperature (A_{e1}) without affecting the core temperature or its properties appreciably. A quench usually follows the heating cycle to produce the desired properties in both case and core.

Flame Hardening: No addition or absorption of other elements occurs during flame hardening, and hardenability of the material alone determines the depth and hardness of case. Since no sharp line of demarcation exists between the hardened surface zone and the core, spalling or flaking during service usually does not occur.

Flat sections, circular paths, irregular shapes, and various combinations may be successfully flame hardened. Part design dictates movement either of the work or of the torch along the work. The flame is kept a reasonable distance from sharp corners to prevent overheating, and drilled or tapped holes are normally protected by being filled with a carbonaceous material. Metal plugs are not used because severe stress concentrations may develop.

Some advantages of flame hardening are: 1. Large machined parts can be surface hardened economically. 2. Surfaces can be selectively hardened with minimum warping and with freedom from quench cracking. 3. Scaling is superficial because of the relatively short heating cycle. 4. Electronically controlled equipment provides precise control of case

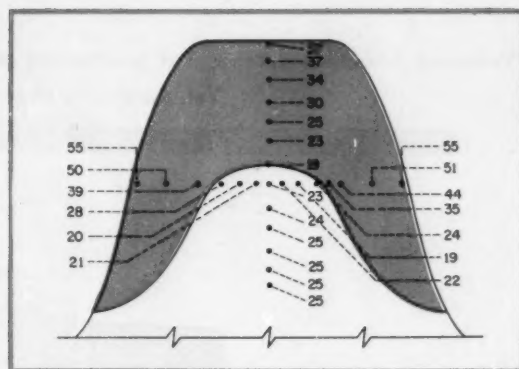


Fig. 6—Rockwell C hardness distribution in SAE 4640 flame-hardened gear tooth.

properties, Fig. 6.

Disadvantages include: 1. A technique must be established for each design to be surface hardened to obtain optimum results. 2. Overheating can cause cracking, or, where thin sections are involved, excessive distortion.

Induction Heating: The most commonly used sources of high-frequency current for induction heating are: 1. Motor-generators with frequencies of 1000 to 10,000 cps and capacities to 10,000 kw. 2. Spark-gap oscillators with frequencies of 100,000 to 400,000 cps and capacities to 25 kw. 3. Vacuum-tube oscillators operating at about 500,000 cps with output capacities of 20 to 50 kw.

Depth of penetration of electrical energy decreases as frequency increases. For this reason, thin-walled sections require high-frequency heating and thick sections require lower frequencies for adequate penetration. Also, part size and shape place certain limitations on effectiveness of surface hardening by this process.

Some advantages of induction heating are: 1. Versatility in selective hardening of both external and internal surfaces. 2. Uniformity of heat-treated parts. 3. Efficient, localized heat concentration. 4. Minimum distortion and oxidation because of the short heating cycle. 5. Ability to harden low-cost carbon steels.

Next article in this series discusses the selection and evaluation of steels for surface-hardening applications.

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Producing fine-pitch gearing that approaches perfect performance is not simple or easy.

Yet, the quality of gearing—in design and manufacture—can often be the

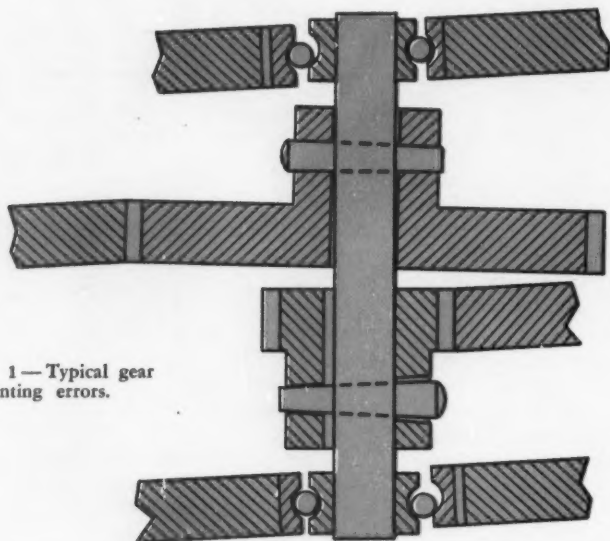


Fig. 1—Typical gear mounting errors.

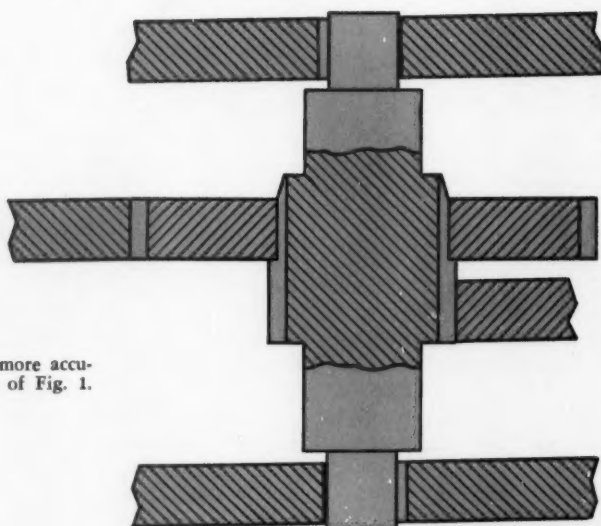


Fig. 2—A more accurate design of Fig. 1.

Summarized here are the critical design, tooling, and inspection factors that mark

the state of the art of

High-Grade Fine-Pitch Gearing

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DISTINCTIVE design considerations set high-grade fine-pitch gearing well apart from other kinds of gearing. Techniques and practices which are important in this field are often of little or no importance in other fields of gearing, and vice versa.

Conventional design practices, for example, are often not conducive to required accuracy. Mounting techniques require special attention in design, manufacture, and inspection. Statistical methods play an important role. Customary methods of specifying dimensions and tolerances are not applicable. Cut-

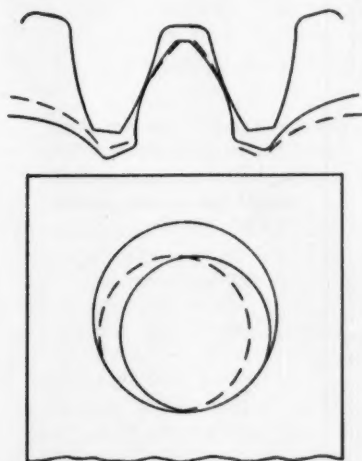


Fig. 3—Backlash not eliminated by anti-backlash gearing.

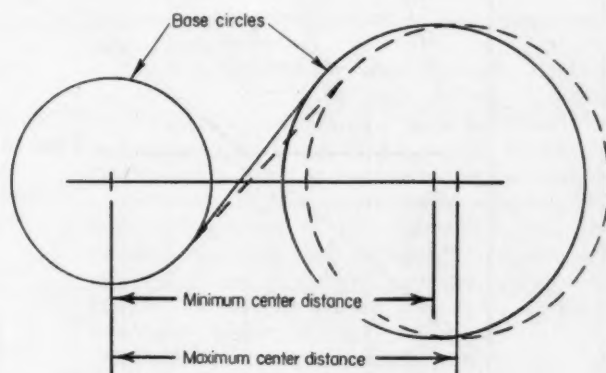


Fig. 4—Maximum and minimum center distances.

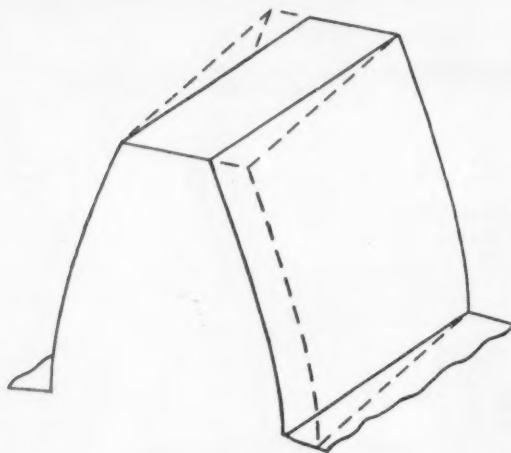


Fig. 5—Effective lead error caused by axis skewness.

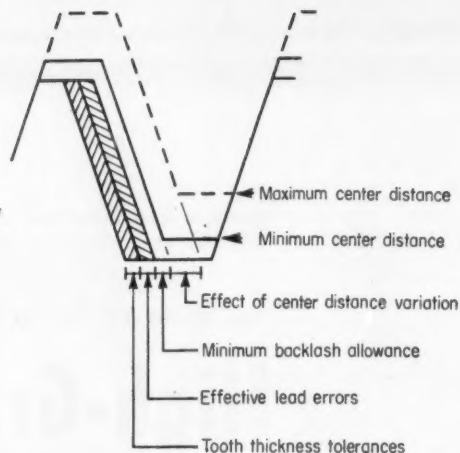


Fig. 6—Factors in calculations for backlash.

ting-tool proportions must be considered.

Many inspection practices are unique, and limitations of measurement appear. For instance, even if perfect, master gears do not necessarily indicate the center distance at which imperfect gears mesh with each other. Similarly, the two-flank roll test is not an effective check for angular error.

Such topics are explored in this article for the purpose of providing a look at the current state of the art. Also, factors limiting improvement of fine-pitch gearing are examined, and directions for continuing effort and development are suggested.

Mounting Methods

Several mounting errors that can affect gear-train accuracy are shown in Fig. 1. A more accurate design¹ is shown in Fig. 2. Spline press fits of 0.0002 to 0.0006 in. are common. Gears can be mounted in many different ways,^{2,3} but designs employing pins, setscrews, keys, sliding splines, split hubs, collets, and locknuts are not conducive to accuracy.⁴ Likewise, ball bearings and antibacklash devices are sources of significant error,⁵ especially when used on slow-speed shafts. Antibacklash gearing, for

¹References are tabulated at end of article.

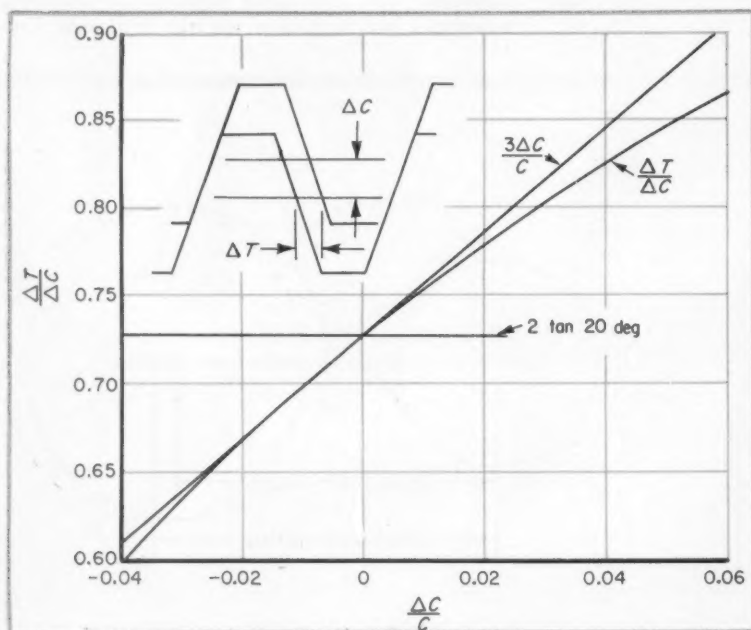


Fig. 7 — Justification for limited use of the general backlash formula.

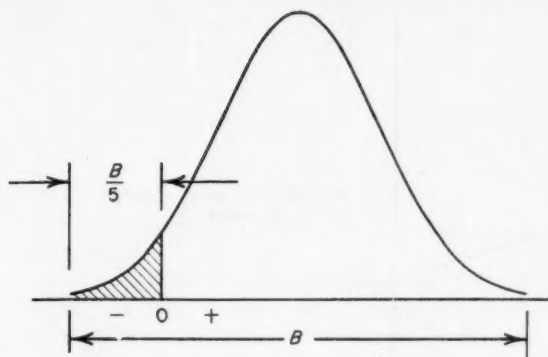


Fig. 8—Backlash distribution.

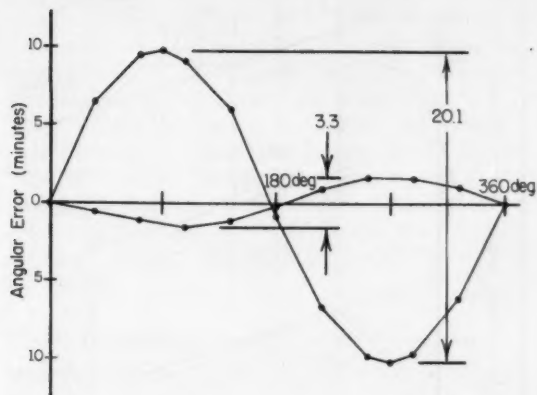


Fig. 9—Angular errors in two gears which have the same total composite error, $TCE=0.0006$ in., and the same diameter, 1 in.

example, aggravates the hysteresis losses caused by friction, deformation, and bearing clearances,⁶ Fig. 3.

Mounting methods can be evaluated on the basis of their effects on center-distance variation and axis skewness. Considerations for control of these errors include tolerances for center distance, parallelism, squareness, clearance, and runout. Also, radial deflections of mounting elements—usually shafts—must be considered. The purpose of these considerations is to determine the maximum and minimum center distances between base circles, Fig. 4, and the "effective" lead errors, Fig. 5. The axial component of axis skewness affects the center-distance variation, and the pitch component causes an effective lead error.

Backlash

After the maximum and minimum center distances and the effective lead errors have been determined, the maximum backlash can be computed, Fig. 6. In particular, these items should be computed:

1. Tooth thickness which corresponds to zero backlash at the minimum center distance.
2. Tooth thickness which corresponds to zero backlash at the maximum center distance.
3. Minimum tooth thickness, by subtracting the minimum backlash allowance, the sum of the maximum effective lead errors, and the sum of the tooth thickness tolerances from Item 1.
4. Maximum circumferential backlash, by subtracting Item 3 and the sum of the minimum effective lead errors from Item 2.
5. Maximum angular backlash (in radians), by dividing Item 4 by the standard pitch radius.

In Items 1, 2, and 3, the computed tooth thickness is really the sum of the circular tooth thick-

nesses on the standard pitch radii. At this stage of analysis, it is neither desirable nor necessary to compute individual tooth thicknesses. Further, it is simpler to work with differences between actual and standard values.⁷ As Fig. 7 shows, it is permissible to use the well-known formula $\Delta T \approx 2 \Delta C \tan 20 \text{ deg}$, provided $3 \Delta C^2/C$ is small compared to Item 4. If the $3 \Delta C^2/C$ value is not small, tables for $\Delta T/\Delta C$ versus $\Delta C/C$ should be used.⁸

In practice, minimum backlash allowance, Item 3, can be slightly negative, that is, a possible but not likely interference. Normally, the amount of overlap can be about 1/5 of the spread between maximum and minimum backlash, Fig. 8, if natural tolerances (process capabilities) are not less than 3/4 of the drawing tolerances.⁹ Under these conditions the actual gear-train backlash usually does not exceed 2/3 of the maximum backlash, Item 4. If the natural tolerances are considerably smaller than the drawing tolerances, the manufacturing distributions can fall on the edges of the drawing tolerances—usually the most-metal side—thus increasing the chance of tooth interference.

Statistical formulas for how tolerances combine are of little value in backlash analysis. Idealized mathematical expressions tend to be burdened with assumptions that do not fit the real-life situation.¹⁰ On the other hand, if manufacturing distributions are available, or if it is practicable to specify the form and position of the distribution (i.e., the standard deviation and average),¹¹ the assembly can be simulated on a digital computer.¹² As a rule, however, the simpler overlap method, Fig. 8, yields satisfactory results.

In addition to tooth backlash it is necessary to consider the gear train backlash due to torsional twist, tooth deflection, hysteresis, and temperature change. Torsional twist and tooth deflection can

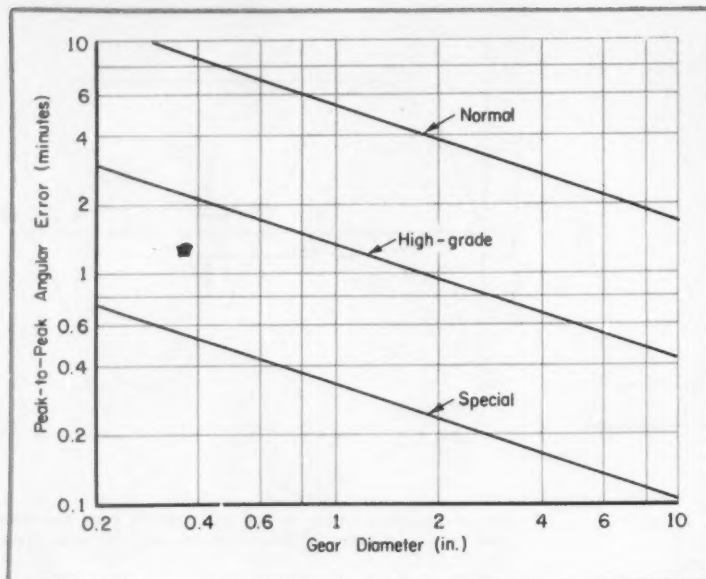


Fig. 10—Guide to angular-error tolerances.

either be computed or determined experimentally. Since hysteresis, Fig. 3, is dependent upon several intangibles, it should be determined experimentally if suspected of being significant. The effect of temperature change can be found from

$$\Delta B = \frac{\Delta T}{\Delta C} \Delta L$$

where ΔB = change in tooth backlash, $(\Delta T)/(\Delta C)$ = average of the $(\Delta T)/(\Delta C)$ factors computed in Items 1 and 2, and ΔL = relative change between the gear and housing center distances.

Angularity

It is well known that the two-flank roll test is not an effective check for angular error,¹³ Fig. 9. Angular tolerances must be specified for gears which transmit angular data. Hence, total composite error (TCE) tolerance and tooth-to-tooth composite error (TTCE) tolerance are redundant. There are numerous sources of angular error, and it is impracticable to predict how the individual errors combine. Several potential sources are independent of the gear generator, namely, operator technique, work-

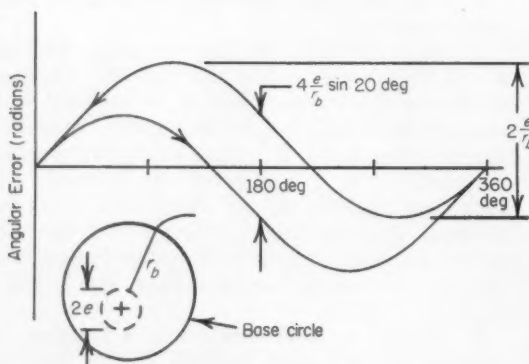


Fig. 11—Effect of journal runout on backlash and angular error.

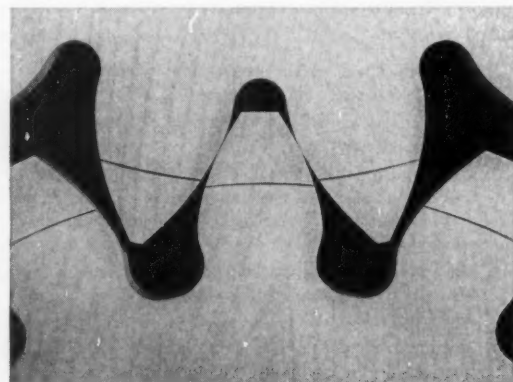


Fig. 12—A work gear (upper) with an exaggerated error in base pitch, engaged with a master gear (lower). The center distance is standard.

Nomenclature Initials

TCE	= Total composite error
TTCE	= Tooth-to-tooth composite error
OR	= Outside radius
OFR	= Outside form radius
IFR	= Inside form radius
RR	= Root radius
DP	= Diametral pitch

holding configuration, blank deflection, and cutting tool sharpness.

A rough guide to angular tolerances is shown in Fig. 10. The "Normal" line denotes quality attained with conventional manufacturing techniques. The "High-Grade" line denotes quality attained with conventional hobbing machines in good operating condition and with better than average work-holding fixtures, blank accuracy, and blank material (homogeneity). The "Special" line denotes techniques equivalent to or better than those found in the manufacture of master gears.⁵

Since typical angular error curves are quite smooth, Fig. 9, maximum angular error can be found by visual or graphical superposition. Of course, this method of analysis is limited to high-ratio trains, that is, trains in which only one or two meshes contribute most of the error. The angular error of low-ratio trains usually does not exceed 2/3 of the maximum possible error.

On data transmission gears, it is especially important that the designer designate clear and unambiguous datum surfaces.¹⁴ On bore-type gears, the bore is usually a satisfactory datum. On shaft-type gears, however, the journals are not usually a satisfactory datum. Necessary clearance between gear journals and inspection bushings can cause erratic errors in measurement. Also, stick-slip bearing friction can be significant. In most cases, the

only practical way of specifying the form and relative alignment of journals is with respect to a centers datum. Of course, design must allow for runout between the journals and centers datum. The effect of sinusoidal runout¹⁵ is shown in Fig. 11. The backlash component is part of the backlash analysis—that is, since the centers datum is the base circle center, the journal runout is part of the maximum and minimum center distances. The angular component is added to the gear angular error. Normally, the effect of journal runout is quite small.

Tooth Dimensions and Tolerances

It is generally acknowledged that the two-flank roll test is the best method of measuring the size of work gears.¹³ In this method a master gear measures the "effective" tooth thickness. Therefore, the drawing specification should read: EFFECTIVE TOOTH THICKNESS—STANDARD $\pm .XXXX$. As a rule TCE and TTCE tolerances are superfluous. In general drawing practice,¹⁶ for example, roundness of a shaft is specified only when it is necessary to control the form to closer limits than the size tolerance. Similarly, TCE and TTCE tolerances should be specified only in cases such as adjustable center and high-speed gears, respectively.

Gears have been specified in many different ways.¹⁷ Clearly, those methods which compel the specification of TCE and TTCE tolerances impose needless burdens on the designer and manufacturer.

Master gears—even if perfect—do not necessarily indicate the center distance at which imperfect work gears mesh with each other.¹⁸ Examples are shown in Fig. 12 and 13. In practice, this effect becomes significant as the effective tooth-thickness tolerance approaches the magnitude of the tooth errors. Thus, in high-grade fine-pitch gearing, it is necessary to

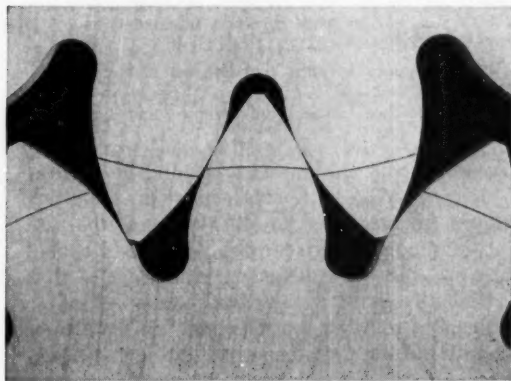


Fig. 13—Two imperfect work gears in mesh. Center distance is less than standard.

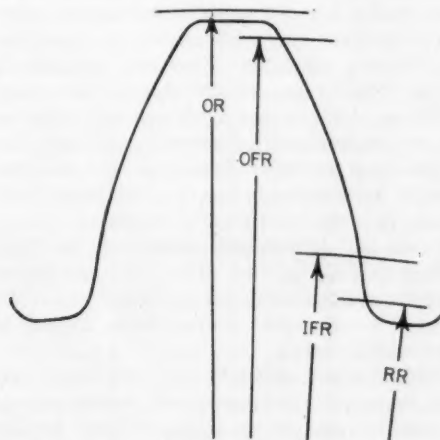


Fig. 14—Radial teeth elements.

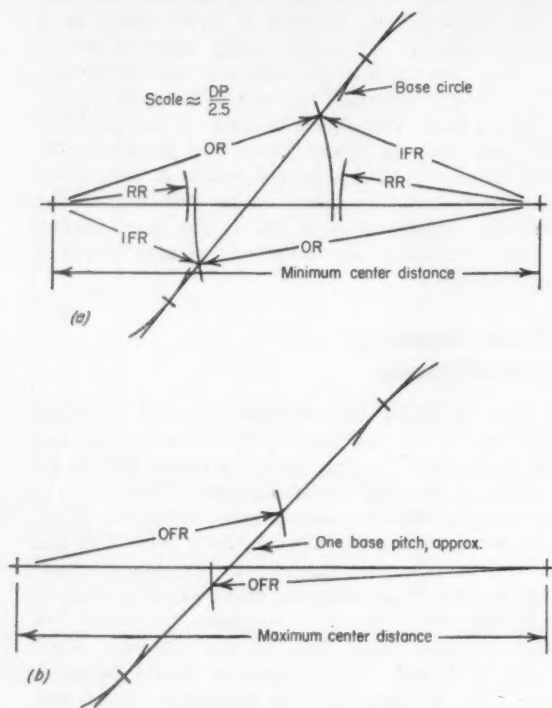
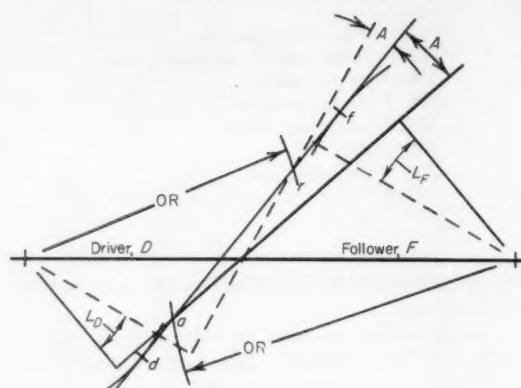


Fig. 15—Graphic tooth layout.



$$A = \text{Angle of friction}$$

$$E = \text{Efficiency} = 100 \frac{N_D L_F}{N_F L_D}$$

L_D, L_F = Angular displacement, driver and follower
 N_D, N_F = Number of teeth, driver and follower

$$S_a = \text{Sliding ratio} = \frac{N_D(a_f)}{N_F(a_d)}$$

$$S_r = \text{Sliding ratio} = \frac{N_F(r_d)}{N_D(r_f)}$$

Fig. 16—Determination of sliding ratio and efficiency.

specify the size of one work gear in terms of a meshing center distance with a mating gear.

Radial tooth dimensions, Fig. 14, can be determined from simple layouts,¹⁰ Fig. 15a and 15b, which preclude tedious calculations. The top land, Fig. 14, must fall on or below the outside radius, OR. The outer end of the involute profile must fall on or above the outside form radius, OFR. The inside form radius, IFR, is the lowest point at which the mating gear can make contact. The bottom of the tooth space must fall on or below the root radius, RR. Note that radius dimensioning allows top-land runout, size, and deburring variations to be traded in the shop, whereas diameter dimensioning requires a tolerance and measurement on each item.

The OR is a maximum dimension and should always be specified as: OUTSIDE RADIUS—.XXX Max. The OFR and IFR are not toleranced because there must be an involute profile between these limits. The RR is usually a maximum dimension, but, in some instances, it is necessary to specify a minimum limit, such as, to prevent defacement of journals.

As a rule, OR is standard, thus fixing the mating IFR and RR, Fig. 15a. The OFR can be reduced to the point of unity contact ratio²⁰ or slightly less, Fig. 15b. Probable contact ratio should be unity or slightly larger.

In designs where sliding¹⁰ and efficiency²¹ are of prime importance (in high-speed meshes, step-up ratios, modified pinions, etc.), the OR and possibly the center distance should be modified.²² It is a

simple matter to determine the maximum sliding ratio and the minimum efficiency on the layout for minimum center distance, Fig. 16. Sliding ratios less than 4 and efficiencies greater than 90 per cent are common.

For equal root clearances (assuming the gears are cut with hobs having equal addendums), individual tooth thickness differences should be

$$\Delta t_1 = X + Y \text{ and } \Delta t_2 = X - Y$$

where

t_1 = Maximum effective tooth thickness, gear 1

t_2 = Maximum effective tooth thickness, gear 2

$$X = \frac{T_{min} + T_{tol}}{2}$$

T_{min} = Sum of the minimum tooth thicknesses, Item 3

T_{tol} = Sum of the tooth thickness tolerances, Item 3

$$Y = [(\Delta OR_1) - (\Delta OR_2)] \tan 20 \text{ deg}$$

ΔOR_1 = Difference between the designed and standard OR, gear 1

ΔOR_2 = Difference between the designed and standard OR, gear 2

Minimum tooth thicknesses are found by arbitrarily splitting ΔT_{tol} and subtracting the resulting tolerances from Δt_1 and Δt_2 . As a check, the sum of the minimum effective tooth thicknesses should equal ΔT_{min} . In some designs it is desirable to shift the nominal tooth thicknesses, for example, to use stock gears or standard master gears. This is accomplished by shifting the nominal mounting center distance.

On occasion, a designed radial dimension cannot

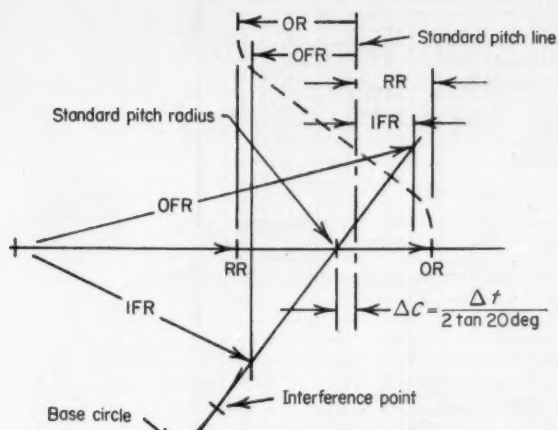


Fig. 17—Radii generated by hobs.

be produced with standard cutting tools. Generated radial dimensions can be found by superimposing the cutting tool dimensions on Fig. 15a and 15b. The case for a hobbed gear is shown in Fig. 17. Each generated dimension is worked out for the worst condition. The generated IFR, for example, is based upon the hob OFR and maximum gear tooth thickness. Of course, undercut will occur if the hob contacts the interference point. In that case, the generated IFR can be found by graphical generation.^{23,24} Also, a modified tooth might be pointed at a radius below the designed OR. The pointing radius can either be calculated or generated graphically.

Pointing and undercut limitations of hobbed gears are shown in Fig. 18. A 17-tooth hobbed pinion, for example, cannot be enlarged beyond $\Delta OR = 1.1/DP$ (assuming the tooth thickness has been correspondingly enlarged to $\Delta t = 2 \Delta OR \tan 20 \text{ deg}$), otherwise, the tooth will be pointed at a radius less than the enlargement. Alternatively, tooth thickness cannot be less than $\Delta t = 2(0.6/DP) \tan 20 \text{ deg}$ (assuming a hob addendum of $1.6/DP$), otherwise some of the profile will be undercut. As a rule, undercut that falls on or below the designed IFR is not detrimental. In fact, undercut that falls on the IFR can be advantageous, in that the mating OR can be increased and yet not adversely affect the sliding and efficiency, Fig. 16.

Manufacture

Unfortunately, hob dimensions are not independent of pitch. The addendum, tip radius, tooth thickness, shaving allowance, fillet radius, and dedendum are expressed in terms of inches, not in terms of pitch. Moreover, many hobs are made to hob manufacturer's tolerances, not to standard tolerances. Consequently, the effective hob OR, OFR, IFR, and RR varies with pitch and manufacturer. It is not uncommon for the effective hob addendum to vary from 1.11 to 1.75 over the range of 20 to 120 diametral pitch.

The number of pitches in present-day use is unnecessarily large, and they are poorly assorted.

Table 1—System of Interchangeable Pitches

Module	Diametral Pitch	Module	Diametral Pitch
0.1	254	0.4	63.5
0.127	200	0.5	50.8
0.16	158.75	0.635	40
0.2	127	0.8	31.75
0.254	100	1.0	25.4
0.3175	80	etc.	etc.

Ratios vary from $80/72 = 1.11$ to $64/48 = 1.33$. A system of evenly spaced pitches, interchangeable with the metric system, is shown in Table 1. The ratios vary from 1.25 to 1.27. Thus, for example, 127 diametral pitch can be interchanged with 0.2 module. About half of the present-day fine and coarse pitches in both systems could be retained. Also, interchangeable pitches would prepare the ground for eliminating the small differences between English and metric basic racks.

Most high-grade gears are hobbed.⁵ Shaving is not necessary, except perhaps on shaped gears. Grinding is usually reserved for hardened gears and gears in the Special classification (see Angularity). Most coatings are detrimental to accuracy, and are usually superfluous. The lapping of assembled gear trains should be avoided, but running-in of assembled trains is beneficial.

The best pitch range for accuracy lies between 32 and 80 diametral pitch. Gears coarser than 32 diametral pitch suffer from distortions caused by metal removal. Gears finer than 80 diametral pitch are subject to tooling limitations,²⁰ small tip tolerances, and burr removal problems. An 8-tooth 80-pitch pinion, for example, is preferable to a 12-tooth 120-pitch pinion.

In the manufacture of shaft-type gears the observed gear and journal runouts can change from one set of mounting centers to another.²⁵ The run-out change is due to the geometrical differences between the mounting centers on the gear generator, journal grinder, and roll tester.

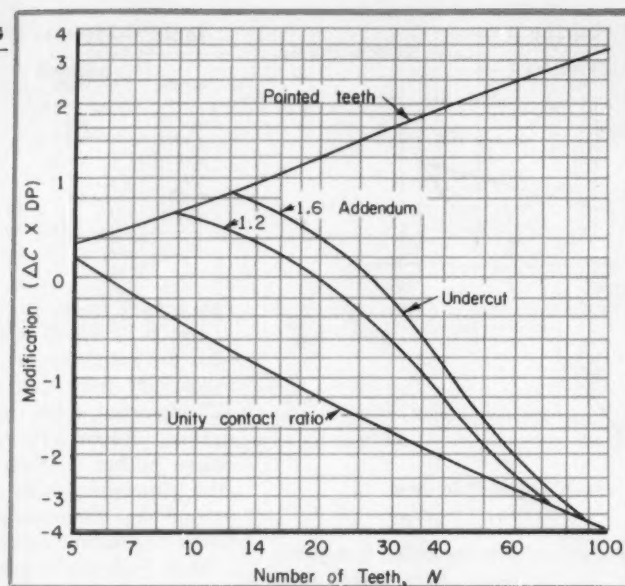
Two-Flank Roll Testing

Gears have been specified in many different ways. Those methods which specify pitch radius tolerances are ambiguous. The measured "testing radius" of a modified pinion, for example, varies with the number of teeth on the master gear.⁸ If specified, tolerances on pitch radius or diameter should be converted into effective tooth-thickness tolerances.

In setting up the roll tester for measuring effective tooth thickness, it is permissible to use the well known $\Delta C \approx (\Delta T)/(2 \tan 20 \text{ deg})$, providing $7(\Delta T)^2/C$ is small compared to the computed center-distance tolerance. If the $7(\Delta T)^2/C$ value is not small, tables for $(\Delta C)/(\Delta T)$ versus $(\Delta T)/C$ should be used.⁸

The master gear should check neither too much nor too little of the work-gear profile. This can be verified by superimposing the master-gear dimensions on Fig. 15a. Specifically, at minimum center distance, the master-gear OR should not extend

Fig. 18—Pointing and undercut limitations of hobbled gears.



much below the work-gear IFR—certainly not below the generated IFR, Fig. 17. And, at maximum center distance, the master-gear OFR should not fall much above the work-gear IFR.

In general, gears cannot be mounted for roll testing in the same manner in which they operate. So-called functional mounting is rare indeed. Gears do not operate in vees, and most gears do not operate on fixed shafts or in fixed bushings. It is usually necessary to mount high-grade gears between centers; otherwise, significant errors in measurement can occur.²⁰ It is the responsibility of the designer to designate unambiguous datum surfaces for inspection purposes,^{14,27} and a journals datum is inherently ambiguous.

Some of the details on axis-alignment and indication requirements of roll testers are covered in Reference 26.

It is highly problematical that a meaningful standard for gear checking speeds and checking loads could ever be written. If attempted, the design of the roll tester, indicator, mountings, and even the gears would have to be specified. What could be standardized, in the opinion of the author, is the method of establishing the correct checking speed and checking load. The same can be said for standardizing the checking temperature. In most cases, it is neither practical nor necessary to take measurements at the standard 68 F. Also, in some applications, it is desirable that the gears and housings be dimensionally correct at a normal assembly temperature, say 77 F.

Angular Testing

It is not unusual for profile and lead error patterns to vary from one tooth to another. This is the reason why observed angular error is often dependent upon the shape of the indexing pawl (ball, cone, flat, worm, gear, etc.). Accordingly, the pawl shape should be functional, namely, two or more gear teeth. Of course, the pawl should make con-

tact at the work gear IFR.

It is fortunate that the great bulk of angular error patterns are relatively smooth, Fig. 9. A smooth error pattern is much easier to measure than an irregular error pattern. In particular, the maximum angular error can be established with as few as 8 to 10 equispaced readings.

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How to determine safe loading of Curved Flanges in Compression

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LOAD-CARRYING capacity of curved compression flanges, Fig. 1, is difficult to calculate by conventional methods of beam analysis because of two factors: 1. Curvature effects. 2. Instability conditions. Compressive stress in the flange

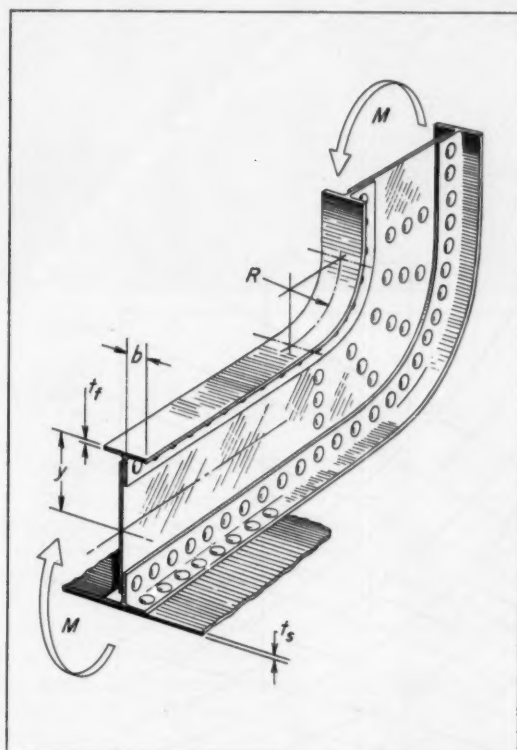


Fig. 1—Typical beam with curved flanges.

Nomenclature

b	= Flange width, in.
E	= Modulus of elasticity, psi
f_c	= Compressive stress in flange, psi
I_{na}	= Moment of inertia about the beam neutral axis, in. ⁴
I_{eff}	= Effective moment of inertia, in. ⁴
M	= Applied bending moment, lb-in.
R	= Radius of flange curvature
t_f	= Actual flange thickness, in.
t_{eff}	= Effective flange thickness, in.
t_s	= Skin thickness, in.
y	= Distance of extreme fibers from beam neutral axis

produces radial components that tend to bend the flange inward, reducing the longitudinal bend stress in the outer edge of the flange. This condition in turn increases bend stress in the flange adjacent to the web.

Methods have been developed for estimating this curvature effect on stresses in curved flanges. However, these methods are cumbersome to use when a number of estimates are required as, for example, in the design of a flange around the corner of a frame where the radius of curvature and flange thickness vary. A simplified procedure for handling such problems is presented here.

Basic Relationships: Flange compressive stress, f_c , can be found from (See Nomenclature)

$$f_c = \frac{My}{I_{eff}} \quad (1)$$

For a curved flange, I_{eff} is calculated using the effective flange width, Kb , where

$$K = \frac{1}{\beta} - \frac{1}{2\pi\beta^3} \quad (2)$$

and

$$\beta = 1.32 \frac{b}{\sqrt{t_f R}} \quad (3)$$

Where the flange radius, thickness, and width are known, the value of K can be determined from the chart in Fig. 2. The effective flange width, Kb , is then used directly to calculate moment of inertia I_{eff} .

If the beam section is nearly symmetrical about the neutral axis, a reasonably accurate approximation for I_{eff} can be made from

$$I_{eff} = \left(\frac{1 + K}{2} \right) I_{na} \quad (4)$$

This value of I_{eff} may be used for a first estimate of f_c , Equation 1. This stress is actually too high, and a final calculation for f_c using the more accurate I_{eff} should be made.

For stability under load, the effective flange stress, f_c , must be less than the allowable flange instability stress, σ_{cr} , for a straight flange. This value is given approximately by

$$\sigma_{cr} = 0.58 E \left(\frac{t_f}{b} \right)^2 \quad (5)$$

or more exactly by curve plots developed by NACA.*

In actual practice, a flange is often attached to

*NACA Technical Notes ARR 3K04 and TN 722, available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

a sheet-metal plate or skin. In this case, the skin thickness must be considered in estimating K , since the skin provides some resistance to flange distortion. A reasonably close approximation of the effective flange thickness can be found from

$$t_{eff} = t_f + \frac{t_s}{2} \quad (6)$$

Example: A curved beam, Fig. 1, with the inner flange in compression, has the following dimensions: $R = 7.5$ in.; $b = 0.8$ in.; $t_f = 0.063$ in.; $y = 1.5$ in.; $I_{so} = 0.5$ in.⁴; $M = 7000$ lb-in.; $E = 10.5 \times 10^6$ psi.

Find the flange instability stress, σ_{cr} , and the effective flange compressive stress, f_c .

SOLUTION: From Equation 4, $\sigma_{cr} = 0.58(10.5 \times 10^6)(0.063/0.80)^2 = 37,700$ psi.

To obtain K from Fig. 2, follow the steps indicated by the key. From $R = 7.5$ on the base line, move vertically to the curve plot for $t_f = 0.063$ in. From this point, move horizontally to the curve plot for $b = 0.80$, then vertically to the K curve. Read $K = 0.61$ on the vertical scale. Then, from Equation 4, $I_{eff} = [(1 + 0.61)/2]0.5 = 0.402$ in.⁴ and, from Equation 1, $f_c = 26,200$ psi.

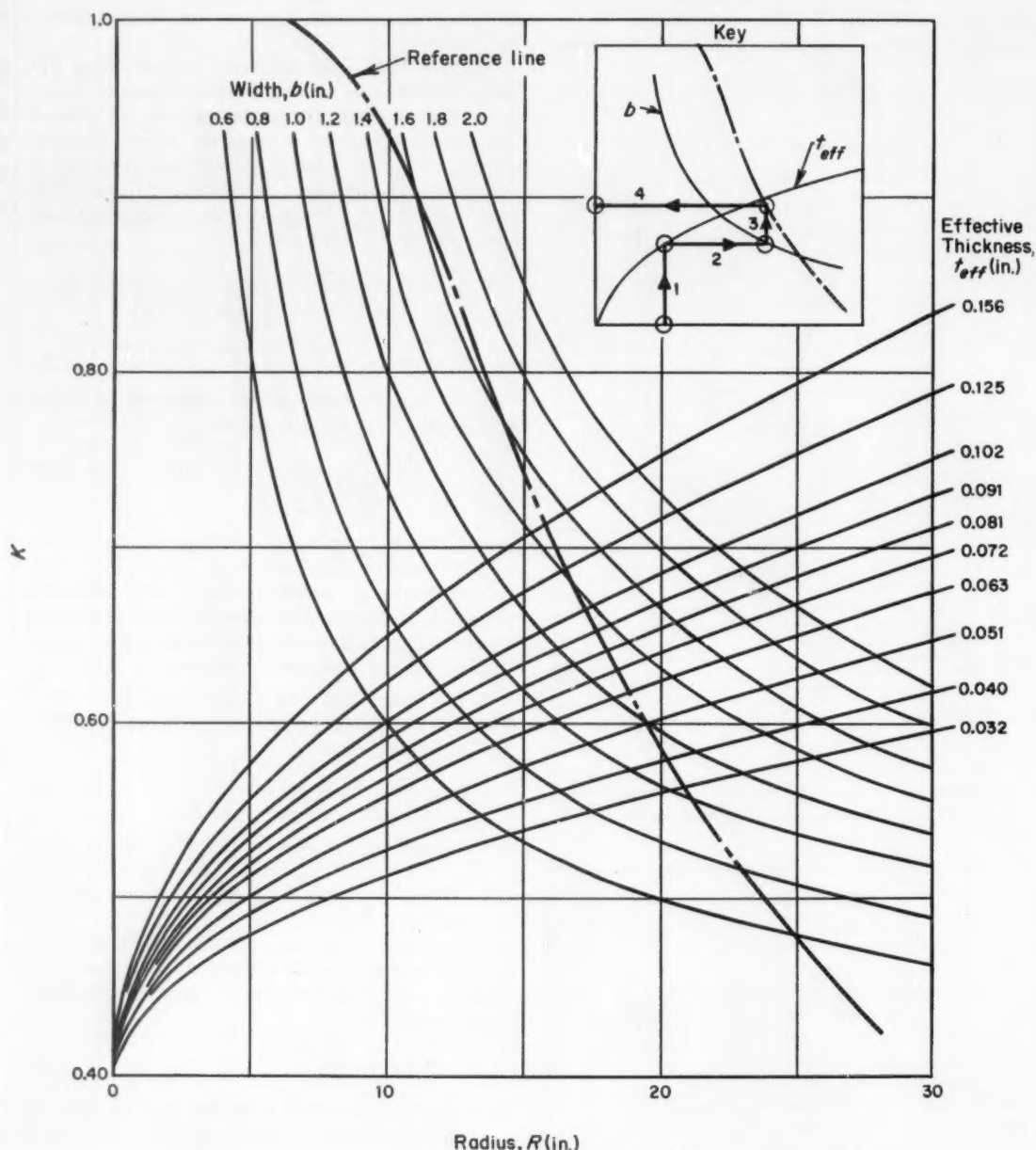
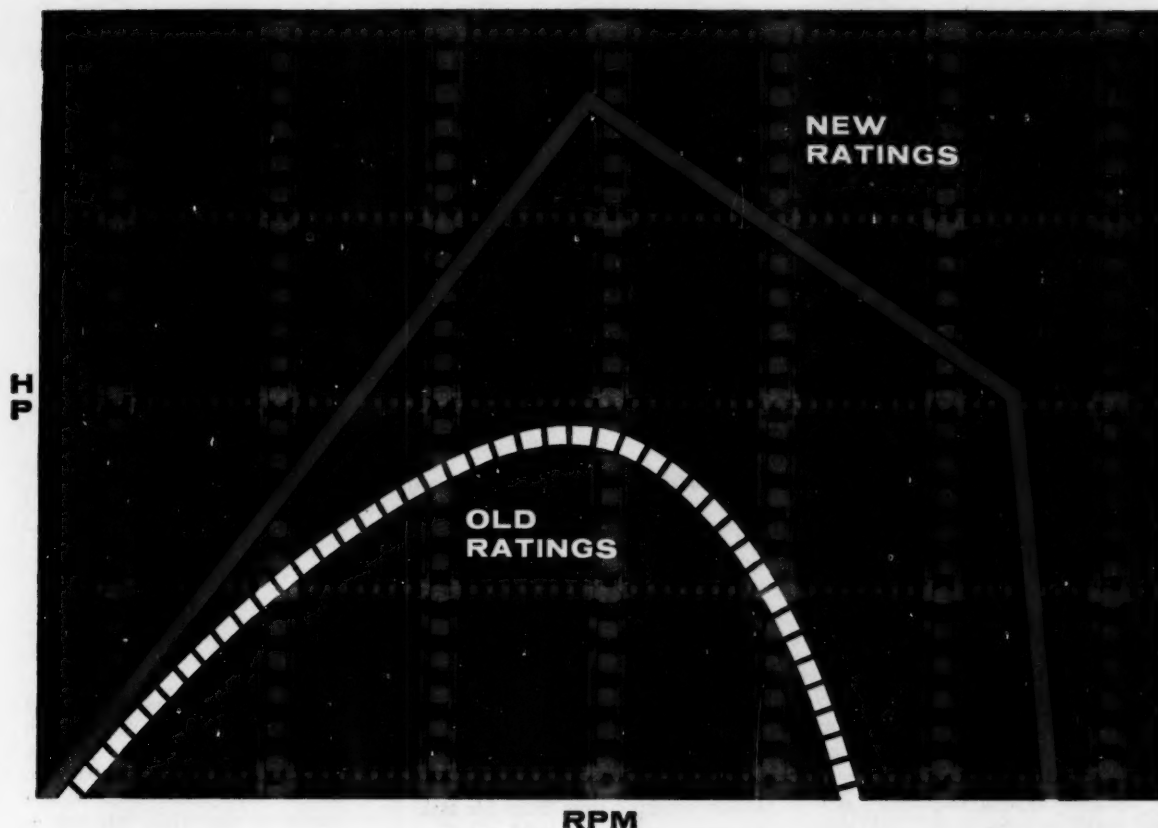


Fig. 2—Values of K for curved compression flanges. For flanges that are not attached to a skin or base member, $t_{eff} = t_f$.



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Design and application factors in

Information Presentation Systems

H. G. McGUIRE and T. L. STODDARD

General Electric Co.
Bethesda, Md.

VISUAL displays are primary means for communication between the human and machine components of an information system. A complete system consists of several machine subsystems, each having a particular function. Output members of complete systems are information presentation subsystems composed of such equipment as printers, plotters, optical projectors, and cathode ray tubes which display information to human viewers. Combinations of system members can provide a wide variety of dynamic displays, Table 1.

The over-all effectiveness of display subsystems depends on the net effectiveness of its three complementary elements: Men, machines, and methods.

The Human Element: Human capabilities and limitations impose certain requirements on machines. With respect to content, information displayed must be of the right quality and quantity, and it must be changed at a rate that will ensure its effective integration into the problem-solving situation. Information may be displayed in textual, graphical, pictorial, tabular, or annotated geographical formats or combinations of these formats. Formats may vary in size, shape, color, and may be dynamic or static. Two essential aspects of man's role as an element of an information pres-

entation subsystem relate to the needs and the capabilities of the human information user.

NEEDS: Information needs of the human observer stem from his task requirements. As a problem-solver and decision-maker, he follows a number of information processing steps: Problem recognition, problem definition, problem confirmation, selection of solution criteria, hypothesis formulation, hypothesis testing, hypothesis selection, action selection and feedback. The design of any information presentation subsystem requires clear specifications of the human observer's information needs.

CAPABILITIES: Important human perceptual skills and visual capabilities are: Light sensitivity, acuity, depth perception, and color perception.

- **Light Sensitivity:** The human eye responds to electro-magnetic radiation within a limited range of 400 to 800 millimicrons in wave length. Light sensitivity depends upon the time that the eye has been exposed to a certain level of illumination.
- **Acuity:** The observer's ability to distinguish the details of an object at specified distances is affected by four interdependent factors: Brightness contrast, illumination, time, and brightness ratio.
- **Depth Perception:** The observer's ability to estimate distance results from two kinds of learning. Each of

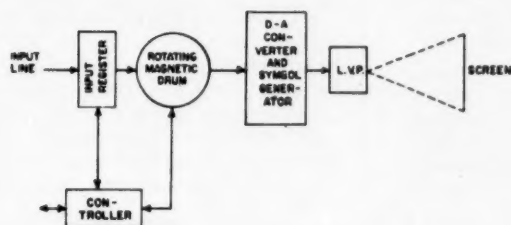
the observer's eyes presents a slightly different view of an object which the observer integrates and perceives as depth. The observer also learns to perceive depth relationships from a number of other visual cues such as differences in the size of objects, overlapping objects, apparent rate of movement, and differences in the clarity of objects.

- **Color Perception:** Normal human observers can distinguish between 300,000 pairs of colors when they are shown side by side. But human memory is limited, and for any display situation an observer can recall and reliably match only ten or twelve colors when they are shown at different times. Certain colors, such as orange or yellow, appear brighter than others. Colors also have subjective meaning for observers. Red, for example, is "exciting" while blue suggests "security."

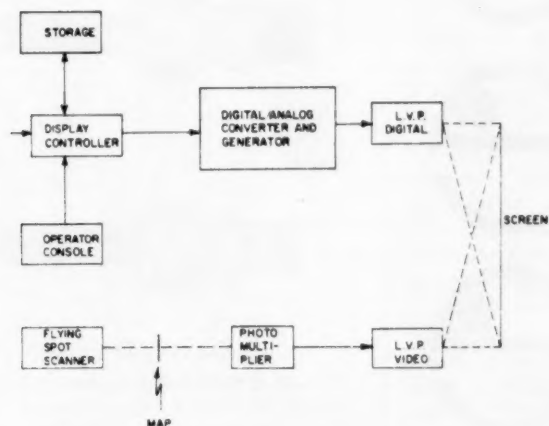
The Machine Element: As the second basic element of an information presentation subsystem, machines have certain problems to solve, certain tasks to perform, and certain capabilities which can be exploited in system design. This equipment consists of three components: The display, a display controller, and a display information storage.

DISPLAY COMPONENT: With regard to the display itself, a wide range of choices exists among machine-controlled equipment. The display devices may be classified by the types of outputs they produce:

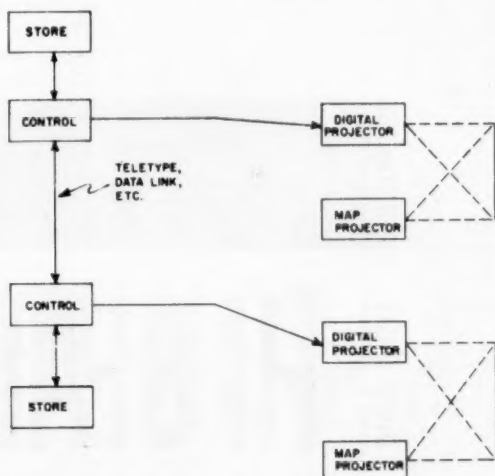
Table 1—Capabilities of Display, Control, and Storage Combinations



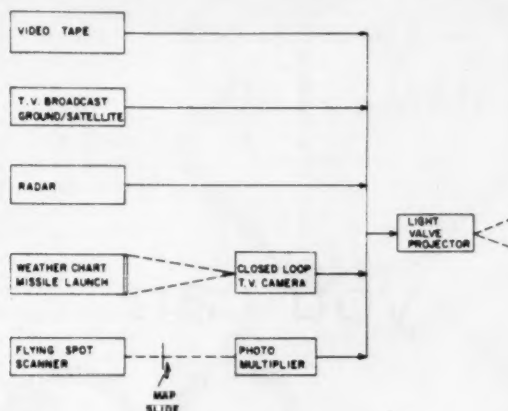
Basic digital system can receive formatted digital information from computers, card or tape readers, and data links. The system has minimum control, no capability to retrieve or manipulate information, and no storage.



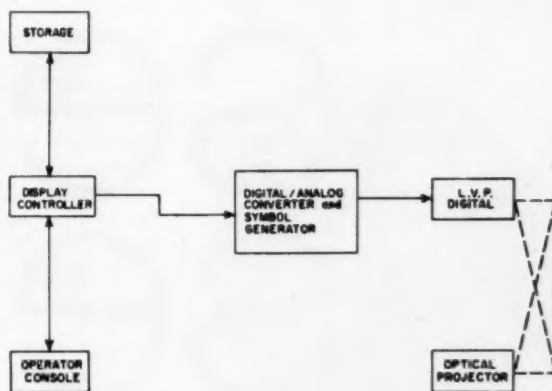
Flexible system has both video and digital elements which can be combined or used independently.



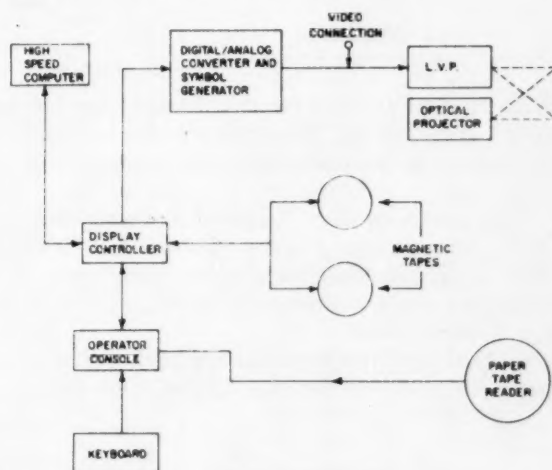
In cross-telling system, displays can be shown at remote locations by transmitting only the digital information over teletype lines, data links, or radio.



Video system can present a large, bright, high-resolution display originating from any of several inputs.



Combined video/digital system includes an optical projector used to provide maps or other backgrounds.



High-speed computer enables system to assume heavy processing load. Formatted display data is transmitted to display controller where it can be displayed or buffer-stored.

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see
see

when it's tight

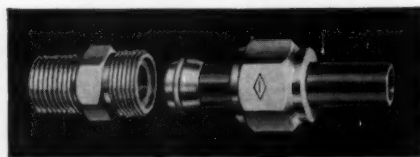


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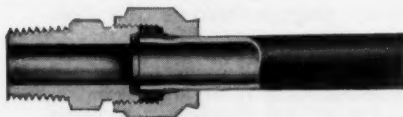
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DESIGN ABSTRACTS

- Printed outputs may be produced by typewriters, line printers, or microfilm or electrostatic printers exposed to cathode ray tubes. The rates of display generation range from 10 to 10,000 characters per second.
- Graphs may be produced by devices ranging from an X-Y plotter to devices using the cathode ray tube principle. The speed of such equipment ranges from 1 to 20,000 points per second.
- Charts and maps may be produced by direct optical projection or by television-type displays. The time required to retrieve one map in a file of 4000 maps may be in the order of 10 seconds.
- Pictorial display equipment includes facsimile devices, direct optical projection, and television-type scanning systems.

DISPLAY CONTROLLER COMPONENT: A second machine component is the display controller which must handle all of the information coming into the system, send it to storage, retrieve it from storage, or process it for the display device which presents it to the decision-maker and problem-solver. In the present state-of-the-art, this implies a computer.

DISPLAY INFORMATION STORAGE COMPONENT: A third machine component is the storage equipment. A storage medium may be categorized according to the form of storage:

- Digital storage mediums include punched paper tape, punched cards, and a variety of magnetic devices, such as magnetic tape, drums, disks, cores, and thin films. Access times to information on bulk storage devices range from a few milliseconds to several minutes.
- Video storage devices include a variety of magnetic equipment and thermoplastic tape. A one-hour program can be stored on 2500 ft of magnetic video tape. The same program can be recorded on 250 ft of thermoplastic tape.
- Photographic storage devices can record on photographic emulsions, and special mediums such as thermoplastic tape.

A wide variety of system capabilities can be achieved by combining existing equipment to form new information presentation subsystems.

The Methods Element: An important class of methods considers the



At a cost comparable to an ordinary restrictor or needle valve, you can have pressure-compensated flow control in your hydraulic circuits.

Rated for pressures to 3000 p.s.i.

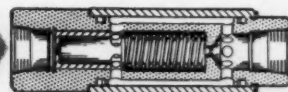
Wide range of sizes available— $\frac{1}{8}$ " to $1\frac{1}{2}$ " N.P.T.F. and $\frac{1}{8}$ " to 1" S.A.E. tube.

Flows to 100 g.p.m. can be controlled.

Factory-calibrated and tested to $\pm 10\%$ tolerance. Closer tolerance available.

Require little more space than pipe or tube in which installed.

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Unit senses pressure drop across precise orifice and reacts to control flow with desired limits.

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W-6108



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Circle 488 on Page 19

up front

and in back

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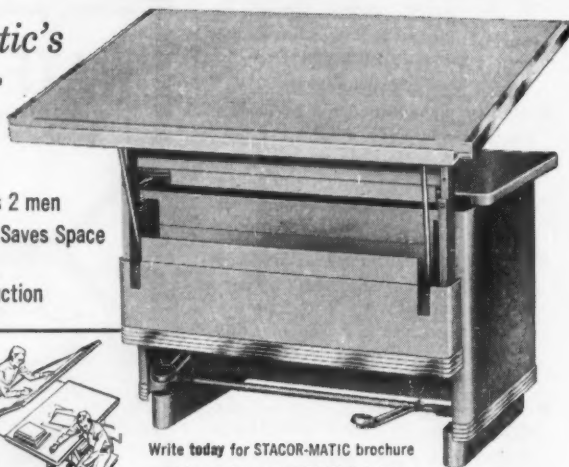
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Circle 489 on Page 19

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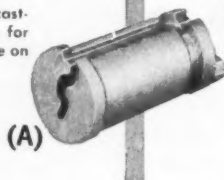
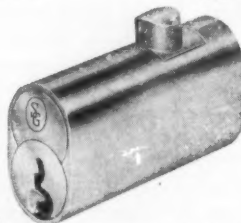
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According to Mr. George Paul, Chief Engineer, Sargent & Greenleaf, Inc., "A number of powdered metal parts producers were contacted to make these low cost, close tolerance, complex parts. Reese was the only one interested. We now find other practical applications and will, of course, use Reese as our prime source".



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DESIGN ABSTRACTS

relationship between the methods used to control the machine in an information presentation subsystem, that is, programming. Display programming is the specifying and coding of routines necessary to instruct a computer to generate the desired displays. A basic programming system is limited to two primary functions: Generating requested displays, and updating information files. Some program routines are: Data conversion, request read-in, request interpretation, map or background selection, data retrieval, data manipulation and computation, data coding, display-controlled data generation, display message makeup, display storage load, and display storage read.

AIEE Paper No. CP 60-1212, "Information Presentation Systems," presented at the AIEE Fall General Meeting, Chicago, Oct. 1960, 12 pp.

materials

High Temperature Stability Of Magnetic Materials

Norman Pavlik, Materials Laboratories,
Westinghouse Electric Corp.

Why most magnetic materials show a significant irreversible change in magnetic properties as a result of exposure to 500 C and return to room temperature.

Cobalt-iron alloys containing from 27 to 50 per cent cobalt can be stable magnetically up to at least 600 C. However, this temperature stability is dependent upon several important considerations. One is the geometry of the test system.

Paper No. 152, "High Temperature Stability of Magnetic Materials," presented at the Sixth Annual Conference on Magnetism and Magnetic Materials, New York, Nov., 1960.

Short-Time Tensile Properties Of Type 316 Stainless Steel At Very High Temperatures

T. W. Gibbs, associate scientist, and
H. W. Wyatt, senior scientist, Research
and Development Div., Avco Corp.

Evaluation of Type 316 stainless-steel sheet material to determine the effects of residual cold-work and welding on the room-temperature

and elevated-temperature mechanical properties to 1800 F. Short-time tensile and tensile-creep elongations tests were run to determine the stresses required to produce elongations up to 10 per cent in 2 min. The effect of welds in tension was to lower the elongation with no loss in strength. The effect of cold-work on the annealed material was to increase appreciably the strength properties, thus allowing for higher design stresses. Type 316 stainless steel retains some strength properties up to 2300 F. A definite stress-strain relationship exists in which the 0.2 per cent yield stress is close to tensile stress.

ASME Paper No. 60-WA-11, "Short-Time Tensile Properties of Type 316 Stainless Steel at Very High Temperatures," presented at the Winter Annual Meeting, New York, Nov.-Dec., 1960, 8 pp.

techniques

Optimum Multivariable Control Systems Design

E. B. Lee, senior research scientist, Minneapolis-Honeywell Regulator Co.

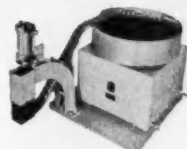
The design of optimum controllers for processes which are described by linear differential equations with one or more independent forcing terms. After presentation of a general method for designing what is usually a nonlinear controller, applications are made to: Design of minimum energy controllers, design of minimum response time controllers, and design of minimum error controllers. Various other design criteria and restrictions on controller parameters are also discussed.

ASME Paper No. 60-JAC-5, "Design of Optimum Multivariable Control Systems," presented at the Joint Automatic Control Conference, Mass. Institute of Technology, Sept., 1960, 6 pp.

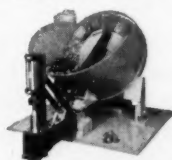
Programmed Pressure By a Digital Servo System

O. K. Kowallis, director of research, Wiancko Engineering Co.

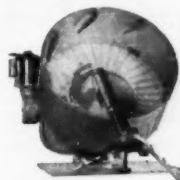
A system for accurate regulation of a contained pressure by means of a digital servo network. The desired pressure is determined by simply selecting a crystal-controlled oscillator frequency. This paper describes in detail the concepts in-



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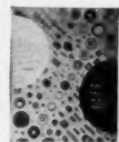
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WRITE FOR BULLETIN 9102

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DESIGN ABSTRACTS

volved in the system development, and indicates the significance of the system for pressure control and calibration problems.

ISA Preprint No. ISA-5, "Programmed Pressure Regulation by a Digital Servo System," presented at the Joint Automatic Control Conference, Mass. Institute of Technology, Sept., 1960, 11 pp.

Lubrication

High-Temperature Lubrication With Vapor-Deposited Coatings

D. J. Baldwin and G. W. Rowe, Tube Investments Research Laboratories, Hinxton Hall, Cambridge, England

Friction of metals which have been coated with inorganic films by reaction with their surrounding atmosphere. Many coatings will prevent seizure and give a fairly constant but high coefficient of friction up to high temperatures. Layer-lattice compounds give much lower friction at all temperatures below those at which the film decomposes or evaporates (about 850 C for molybdenum disulphide). A film of boron nitride formed on boron shows a high intrinsic friction, but this can be reduced by certain vapors or by raising the temperature above about 800 C. Films are shown to be effective under kilogram loads. A simple indentation test shows that a film formed by heating stainless steel in CCl_2F_2 will lubricate at 400 C when the steel is deformed 50 per cent.

ASME Paper No. 60-Lub-4, "Lubrication at High Temperatures with Vapor-Deposited Surface Coatings," presented at the ASME-ASLE Lubrication Conference, Oct., 1960, 6 pp.

bearings

Ball Bearings in Gases At High Temperatures

K. G. Eickhoff and A. White, United Kingdom Atomic Energy Authority, Capenhurst, Chester, England

Ball bearings running at 100 rpm without lubrication in hot gaseous environments under thrust loads. Performance, worse than when running under lubricated conditions, is significantly affected by the environment. In nitrogen, at temperatures of 200 C and 250 C, load-

carrying capacity is only 2 per cent of the capacity for lubricated operation at normal temperature. Best results are obtained with full type, cageless, angular contact bearings. In carbon dioxide, however, at 325 C and 375 C, loads of up to 30 per cent of the lubricated capacity are achieved with deep groove, caged bearings. Similar bearings in a 16 per cent Cr stainless steel performed even better up to 50 per cent of the lubricated capacity. Unlike fatigue failures encountered under lubricated conditions, these bearing failures were caused by wear.

ASLE Preprint No. 60 LC-5, "The Performance of Ball Bearings in Nitrogen and Carbon Dioxide at Elevated Temperatures," presented at the ASLE/ASME Lubrication Conference, Boston, Oct., 1960, 11 pp.

mechanical

Analysis of Deflection Of Thin Cantilevers

R. Frisch-Fay, lecturer, School of Civil Engineering, The University of New South Wales, Sydney, Australia

A proposed new method for the calculation of large deflections. Slender bars under point loads are traced back to the strut problem, thus bypassing the solution of nonlinear differential equations.

ASME Paper No. 60-WA-17, "A New Approach to the Analysis of the Deflection of Thin Cantilevers," presented at the Winter Annual Meeting, New York, Nov.-Dec., 1960, 4 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill.; papers 50 cents to members, 75 cents to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ISA—Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

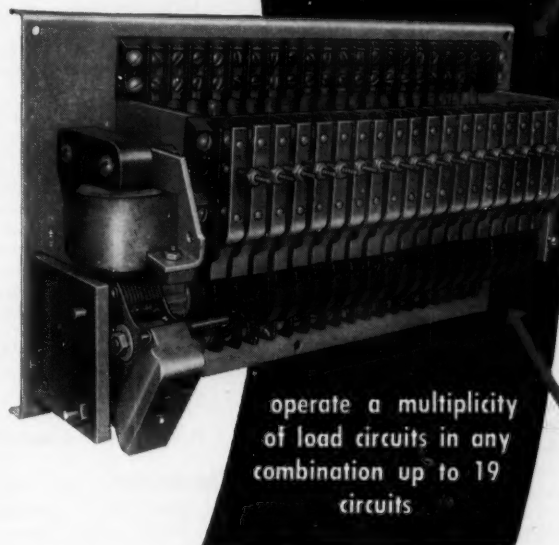
Sixth Annual Conference on Magnetism and Magnetic Materials, sponsored by the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., and the American Institute of Physics, 335 East 45th St., New York 17, N. Y.

A NEW APPROACH TO MACHINE PROCESS CONTROL

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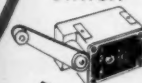
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device to advance
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operate a multiplicity
of load circuits in any
combination up to 19
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when used with multiple indexing
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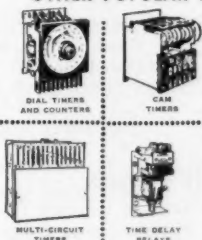
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Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Flareless Tube Fitting

Bulletin 4323B1 illustrates and fully describes Ridg-lok flareless tube fitting, made in stainless steel for corrosion-resistant services. Diagrams of shapes with nomenclature and size tables provide ordering information. 4 pages. Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 601 on Page 19

Structural Steel

Superior mechanical properties and corrosion resistance of Pitt-Ten light-weight, high-strength structural steel are described in new bulletin. Properties of three types of the material, for various applications where weight-strength ratio is a factor, are covered in the illustrated folder. Complete chemistry, mechanical properties, and engineering data are given. 4 pages. Pittsburgh Steel Co., P. O. Box 118, Pittsburgh 30, Pa.

Circle 602 on Page 19

Pressure Test Gages

New catalog describes Bourdon tube gages for use as test standards in the calibration of other instruments and in laboratory analysis. Principle and history of the tubes is discussed, as well as design features and recent developments. New thermal compensator which holds the gage in calibration through ambient temperature changes from -25 to +125 F is described. Adjustment which permits simple, highly refined calibration adjustment is also illustrated and described. Complete information is given on dial sizes, mounting dimensions, and prices. 16 pages. Heise Bourdon Tube Co., Brook Road, Newtown, Conn.

Circle 603 on Page 19

Spring and Diaphragm Actuators

Series B-10 and B-20 spring and diaphragm actuators are illustrated and described in Bulletin B-1020-7. Bulletin shows actuators in various typical combinations, including butterfly valve, adjustable-port valve, and burner valve. Complete specifications, operating characteristics, and dimensions are listed. 4 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

Circle 604 on Page 19

Motorized Drives

Bulletin MD-1 describes full line of gear motors and Line-O-Drive coupled speed reducers. In addition to descriptive and performance data, two full pages of selection tables tabulate various output speeds

for each horsepower rating in all three AGMA classes. Bulletin lists numerous typical applications, pointing out that uses are for a drive requiring "slower-than-motor" speeds. 6 pages. Howell Electric Motors Co., 16316 W. Seven Mile Rd., Detroit 35, Mich.

Circle 605 on Page 19

Centrifugal Pumps

Bulletin 720.5 describes Model 3199 centrifugal pump. Detailed specification data are presented, including description, photograph, dimensional drawings, tables of interchangeability, construction details, and ratings. 4 pages. Goulds Pumps Inc., Seneca Falls, N. Y.

Circle 606 on Page 19

Silicone Modified Rubber

New two-color technical manual on silicone modified rubber explains applications of the rubber in the rocket and missile industries. Material includes various types of compounds, insulation data, and plastic laminates. One page compares neoprene, natural GR-S, Buna-N, and Butyl rubbers for various mechanical characteristics. Glossary of words and terms used in the rubber industry is included. 48 pages. Stoner Rubber Co. Inc., 10792 Knott Ave., Anaheim, Calif.

Circle 607 on Page 19

Appliance Thermostat

Data Bulletin DD-THSN-27 describes new Klaxon Series 20450 appliance thermostat with internal line-voltage heater. Unit is designed so that when the heater is used, heat anticipation is available to supplement response to ambient temperature. Bulletin gives description, operating characteristics, dimensional drawings, and suggested wiring diagrams. 2 pages. Commercial Controls Dept., Metals & Controls Div., Texas Instruments Inc., Versailles, Ky.

Circle 608 on Page 19

Silicon-Rectifier Stacks

Bulletin 6.315 contains information on the specification and application of silicon-rectifier stack assemblies. Bulletin includes specifications, dimensions, and typical performance curves on stacks incorporating 20 or 35-amp silicon rectifiers. 4 pages. Rectifier-Capacitor Div., Fansteel Metallurgical Corp., North Chicago, Ill.

Circle 609 on Page 19

Power-Supply Modules

"The Inside Story of the New Plug-In Power Supply Modules" gives a detailed,

graphic account of the design achievements attained in latest miniature plug-in modules, and tells how they prevent malfunction of associated apparatus. Each specification of the modules is defined and explained in detail. Interesting examples make clear the dangers inherent in inferior specifications. Comparison chart is provided to compare the new modules with other available units. 18 pages. Valor Instruments Inc., 13214 Crenshaw Blvd., Gardena, Calif.

Circle 610 on Page 19

Temperature Controls

Catalog G-25 shows complete line of differential-expansion temperature controls, including a general description of their operation together with a picture and brief specifications of each model. Both electric and pneumatic instruments are covered. They are available for temperatures to 2000 F. 4 pages. Burling Instrument Co., 16 River Rd., Chatham, N. J.

Circle 611 on Page 19

Silicon, Selenium Rectifiers

Condensed Catalog 100 describes complete line of certified silicon and selenium rectifiers. Cutaway drawings illustrate the construction features of the units, and a full list of more than 350 JEDEC types of silicon rectifiers available is included. Complete electrical and mechanical specifications are listed in individual tables. Curves display forward current rating levels, and derating curves for raised ambient temperatures are also given. 8 pages. Semiconductor Div., Syntrol Co., Homer City, Pa.

Circle 612 on Page 19

Bronze Bushings

New catalog pictures and describes many bronze bushings, and gives a list of applications. One page contains a list of 20 popular SAE brass and bronze alloys, giving their chemical composition and physical properties. 4 pages. Markey Bronze Bushing Co., Delta, Ohio.

Circle 613 on Page 19

Flexible Tubing

"Facts About Spiratube" provides information on the construction and uses of flexible tubing. Booklet gives specifications for the lightweight, rugged, portable duct which is used for ventilation, materials handling, and fume and dust-removal systems. 4 pages. Flexible Tubing Corp., Guilford 2, Conn.

Circle 614 on Page 19

FASTENOMICS

TIPS ON FASTENER APPLICATIONS BY STANSCREW

Coarse Threads . . . Fine Threads . . . Which One . . . When?

What's the difference?

Coarse threads conform to Unified National Coarse (UNC) standards while fine threads are governed by Unified National Fine (UNF) standards. Both include precise, detailed specifications for all thread dimensions and proportions.

UNF standards specify substantially more threads per inch. The following table illustrates the range of difference in various diameters.

Diameter of Fastener	UNC Threads Per Inch	UNF Threads Per Inch
¼"	20	28
⅜"	16	24
½"	13	20
¾"	10	16

Coarse thread advantages

For the great majority of applications, fasteners with coarse threads are used because of these advantages:

1. They assemble easier and faster . . . provide a better start with less chance of cross threading.
2. Nicks and burrs from mass handling are less liable to affect assembly.
3. More clearance provided for plating.
4. Less liable to seize in temperature applications and in joints where corrosion will form.
5. For threading into lower strength materials, coarse threads are less prone to strip.
6. Extreme difficulties are encountered in attempting to tap fine threads in brittle or friable material.

Fine thread advantages

In some applications, fine threads provide a superior solution because of these advantages:

1. They are some 11% stronger than coarse threads due to greater cross-sectional area.



Two ⅜" x 1" socket cap screws. Coarse thread (UNC) has 16 threads per inch; fine (UNF) thread 24.

2. In very hard materials, fine threads are easier to tap.
3. They have better fatigue life than coarse threads.
4. They can be adjusted more precisely when a cotter key is used.
5. Where the length of engagement is limited, where a smaller lead angle is required, or where the wall thickness requires a smaller thread, fine threads should be used.

Don't overload inventory

In trying to establish the best possible fastener for each application, don't stock too many fasteners and overload your inventory. A good rule of thumb is "one thread for a given size and grade of fastener" . . . choosing the type of thread which is best for all applications involving that size and grade. In many cases this will boil down to a coarse thread, since the group will probably include a tapped hole in a friable or low strength material.

For further information

For more detailed information, or the answer to a specific problem, call in your Stanscrew fastener specialist. He is quickly available through your local Stanscrew distributor . . . also your source for Stanscrew's complete line of over 5,500 different types and sizes of dependable fasteners.



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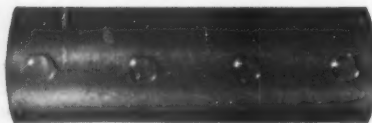
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HELPFUL LITERATURE

Thin-Section Bearings

Suggestions for replacing small-bore, heavy-section standard bearings with 4 to 40-in. bore, thin-section bearings are included in Reali-Slim Bulletin S-109. Bulletin includes a description of Type CP Conrad ball radial bearings available in 90 sizes. Special Reali-Slim bearings are also described. Complete chart of ball bearings in seven series is included in the bulletin, and a second chart lists standard sizes of Series KT single-row, taper-roller bearings. Many line drawings are included. 4 pages. Kaydon Engineering Corp., Muskegon, Mich.

Circle 615 on Page 19

Air Valves

Headline fluid-power valves in 25 types are described in Bulletin 323. Publication contains specifications, features, and response time of the lightweight, poppet-type control units. Complete engineering data are provided for all models, grouped in straightway, three, and four-way types with various solenoid and air-operated heads, and in pipe size; from 1/4 to 1 1/2 in. 8 pages. Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich.

Circle 616 on Page 19

Relay Conversion Kits

Publication PL12-35-960 is suitable for three-ring binders or for use as a wall chart. Color-coding information is given on selective conversion kits for modifying Type PM relays. Seven color-location diagrams show how and where to use kits on standard mounting plates. Coil-application data show how to select magnet coils for relays with any possible circuit arrangement. 8 pages. Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.

Circle 617 on Page 19

Lettering Set

No. 8935 Doric lettering set is described in pocket-sized bulletin. Illustrations include photographs of each of the seven pieces of the lettering set, and of the wooden carrying case. Also shown are samples of the letter faces and sizes that can be drawn. 6 pages. Keuffel & Esser Co., Third & Adams Streets, Hoboken, N. J.

Circle 618 on Page 19

Industrial Phototubes

"Phototubes in Industry," Bulletin PA-220, describes high-vacuum as well as gas phototubes, photomultiplier tubes, photocells, and photoresistive cells. Typical applications are shown for photoresistive cells in combination with transistors. Effects of temperature, excessive illumination, and other environmental conditions are described. Bulletin describes test methods and gives suggestions for servicing equipment using photosensitive devices. CBS Electronics, Div., Columbia Broadcasting System Inc., 100 Endicott St., Danvers, Mass.

Circle 619 on Page 19

Photocopy Products

Two-color brochure is of interest to users and prospective users of photocopying machines and photocopy papers. It illustrates and describes complete six-point photocopy program from one source. Brochure defines characteristics and sizes of stock photocopy papers, gives manipulation instructions, and offers constructive suggestions for correcting common operating problems. 16 pages. Haloid Xerox Inc., Dept. 222, Rochester 3, N. Y.

Circle 620 on Page 19

Custom Motorpumps

Bulletin A-5258 describes custom-designed motorpumps for aircraft, missiles, and spacecraft. Bulletin provides dimensional data and operating ranges of fixed-displacement, variable-displacement, and vane-type motorpumps. Basic information necessary to develop a custom-designed unit is presented. Photographs and installation drawings of typical units are included. 8 pages. Vickers Inc., Div., Sperry Rand Corp., Detroit 32, Mich.

Circle 621 on Page 19

Plastic, Chemical Materials

Brochure CDC-381 describes complete line of polycarbonate resins, phenolic resins, varnishes and molding powders, and fused magnesium oxide. Catalog covers product features, applications, and detailed technical data on Lexan polycarbonate resins and phenolic molding powders. Also described are phenolic laminating varnishes, phenolic foundry resins, Methylon coating resins, phenolic industrial resins and varnishes, and electrically fused magnesium oxide. Many tables and charts are used to point out technical data. 12 pages. Chemical Materials Dept., General Electric Co., One Plastics Ave., Pittsfield, Mass.

Circle 622 on Page 19

Calculator Kit

Truflex nomograph calculator is a tool for plotting sample sizes of thermostatic bimetal for simple beams, cantilever beams, spiral and helix coils, and U-shapes by means of graphic charts. Consisting of two imprinted acetate sheets and a 4-page technical-data bulletin, the kit is packaged in a three-hole-punched envelope for easy filing. Metals & Controls Div., Texas Instruments Inc., 34 Forest St., Attleboro, Mass.

Circle 623 on Page 19

Flat-Belt Pulleys

Complete line of Sure-Grip flat-belt pulleys in face widths from 2½ to 12 in. and ODs from 4 to 46 in. is described in Bulletin 22103. Both straight and crown-face types are available from stock. Interchangeable tapered bushings provide a full range of bores with only four bushing sizes. Tables, photographs, and a line drawing provide all dimensional data. 4 pages. T. B. Wood's Sons Co., Chambersburg, Pa.

Circle 624 on Page 19



"There's no substitute for experience"

During the past 40 years General Industries has produced millions of electric motors for users throughout the world . . .





It's literally true that any device or machine is only as good as the motor that powers it. That's why leading manufacturers around the world prefer to rest their reputation on GI Smooth Power motors. They know that with 40 years' experience in designing and building sub-fractional hp motors for every requirement, GI can be counted on to produce the best motor for the job, at the lowest possible price. Next time you have to make a decision on a motor, remember, "There's no substitute for experience." Specify GI motors: quality-proved, millions of times over!

SMOOTH POWER

AC MOTORS

1/1800 H. P. TO 1/35 H. P.

Quantity price quotation on Request



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THE GENERAL INDUSTRIES CO.

DEPT. GK • ELYRIA, OHIO

HANNIFIN *Crown*

delivers air the way you want it!



With "Crown" remote controlled units, you can filter and drain overhead air lines, control regulators from below, and fill lubricators without climbing. Or, with our completely standard units...

... you can provide just the right amount of filtered, regulated and/or lubricated air right at your machine.

NEW! PULSE-LUBE... for off-beat air flow

If air flow is uphill or light or so infrequent that air-borne lubrication won't solve your problem, you can deliver oil just where you need it, in the exact amount you need, through a tiny flexible tube with new "Crown" Pulse-Lube...

All these "Crown" developments are detailed and described in a new, comprehensive "Crown" catalog (our Bulletin 0400-B1).

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A DIVISION

515 South Wolf Road • Des Plaines, Illinois

PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

3071-PH

HELPFUL LITERATURE

Seal-Ring Assembly

Combination of nonextrusion rings, seal protector rings, and an O-ring is described in new bulletin. Many applications for the unit are pointed out. Assembly can be used in any application, either static or dynamic, where an O-ring is used. Cross-sectional drawing shows the placement of the seal-ring assembly components. 4 pages. Bowen Itco Inc., P. O. Box 4587, Houston 13, Tex.

Circle 625 on Page 19

Band Clamp

Bulletin OEM-760 pictures and describes Type RM band clamp for heavy-duty applications. Details are given in line drawings, and chart of sizes is provided. Two other types of clamps are also detailed, with sizes and line drawings included. 2 pages. Wittek Mfg. Co., 4305-43 W. 24th Place, Chicago 23, Ill.

Circle 626 on Page 19

Ball Joints

Catalog 250 details information on how to provide for movement and flexibility in metal piping with simple ball joints. Illustrations of the five basic motion principles of the joints serve as a key to many examples given. Actual installations are shown and explained. Sections of the catalog cover ball joints in sizes from 1/4 through 16 in., and joints for high temperatures and pressures. Barco Mfg. Co., Dept. J-20, 501 Hough St., Barrington, Ill.

Circle 627 on Page 19

Bearing Alloy Metals

Described in new bulletin are two metals, Carbonite and Nickelite, available for use in bearings. Carbonite is a lead-base bearing alloy metal, and Nickelite, a tin-base babbitt metal. Section on rebarbitting with these two alloys is included, as well as an extensive list of applications. Physical characteristics of the two metals, as compared with ASTM standards, are given in a chart. 8 pages. Carbonite Metal Co., Burlington, Wis.

Circle 628 on Page 19

Pressure Snubber

Diaphragm-seal pressure-snubber unit for sealed systems is described in a new brochure. Detailed drawings show how the device operates. Cross-sections of two diaphragm-seal housing assemblies are shown. Simplified initial charging of the system without loss of filling liquid from the bourdon tube, and solid filling of seal, snubber, and gage assembly are also described. 4 pages. Chemiquip Co., 36 E. 10th St., New York 3, N. Y.

Circle 629 on Page 19

Explosive Valves

Bulletin 1160XV illustrates and describes new Con-O-Cap explosive valves, featuring reusable bodies and replacement kits. All dimensions and specifications are given for the units in tables, drawings, and photographs. 4 pages. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

Circle 630 on Page 19

Wing Nuts

Bulletin 2004 is a stock list of special wing nuts. Engineering drawings describe basic wing nuts with special bosses available. Tables list many blank and special thread combinations, as well as blank and untapped hole-diameter combinations. Engineering drawings of nuts with special counterbores are also shown. 4 pages. Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.

Circle 631 on Page 19

Pressure Gages

Publication 1819 provides information on various types of pressure gages for the process industries and for heavy-duty equipment. Selection chart and chart of standard dials are included. All dimensional and engineering data on the various units are provided. 12 pages. United States Gauge Div., American Machine & Metals Inc., Sellersville, Pa.

Circle 632 on Page 19

Induction Motors

Bulletin 1150, Publication AEB450.6, covers electrical and mechanical features of redesigned squirrel-cage, guarded, drip-proof motors in NEMA standard frames 182 through 445U. Colorful cut-away drawings and photographs point out the features of the units. Table of motor application information is provided, and photographs show actual installations. 8 pages. Electrical Div., Fairbanks, Morse & Co., 303 N. Henderson, Freeport, Ill.

Circle 633 on Page 19

Motor Controls

Several types of motor controls are described in new catalog. These include electronic units, adjustable transformers, and rheostats. Units are pictured and dimensional data are given. Gear head motors for use on the various controllers are shown, and all specifications are included. 21 pages. Gerald K. Heller Co., P. O. Box 4426, Las Vegas, Nev.

Circle 634 on Page 19

Mechanical Tubing

Bulletin T-459 covers electric-resistance-welded, carbon-steel mechanical tubing, Lectrosodic cylinder tubing, and JIC hydraulic line tubing. Booklet includes a discussion of the Lectrosodic process, details tube characteristics, and supplies ordering information. 8 pages. Tubular Products Div., Babcock & Wilcox Co., Beaver Falls, Pa.

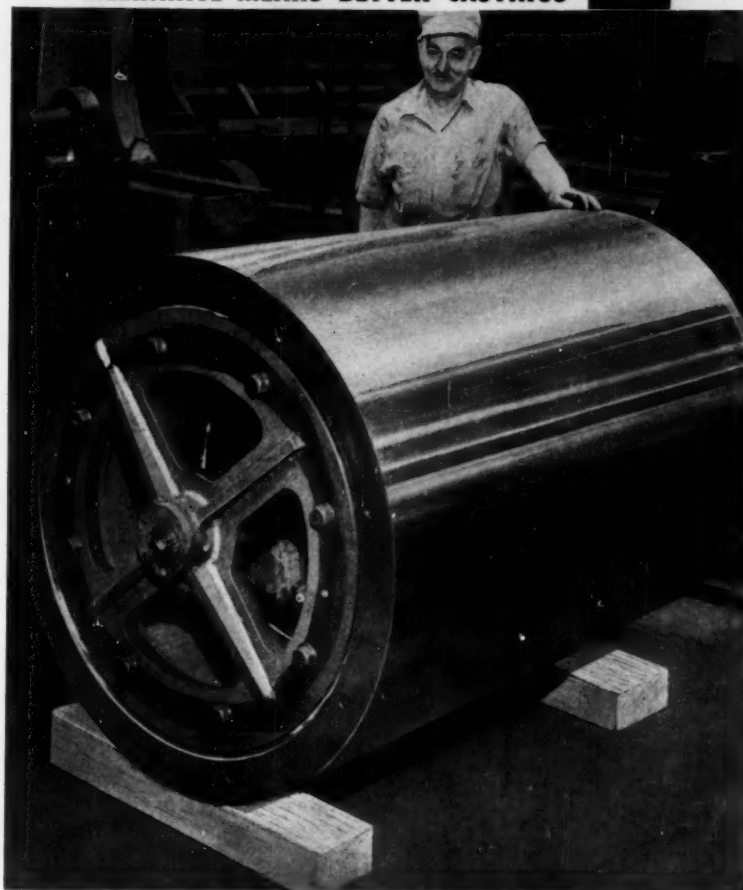
Circle 635 on Page 19

Printed-Circuit Board

Econo-Grid paper-base epoxy, printed-circuit board is discussed in a new catalog sheet. Applications, technical description, stock sizes available, and prices are detailed. Advantages of use of the board are enumerated. 2 pages. Elgin Laboratories Inc., Waterford, Pa.

Circle 636 on Page 19

MEEHANITE MEANS BETTER CASTINGS®



Meehanite Mandrels Reduce Tooling Costs

This 44" diameter by 64" long cylindrical mandrel weighs 8000 lbs. and is used for hydrosponning high strength missile casings. Many such Meehanite mandrels are now being used with good results to form parts for airframes, aircraft engines, missiles and other industries.

If you are producing conical, cylindrical and contoured parts by the power spinning process, Meehanite mandrels, that are machined, heat-treated to a hardness of about 50 Rockwell C and ground, offer many design, economic and production advantages.

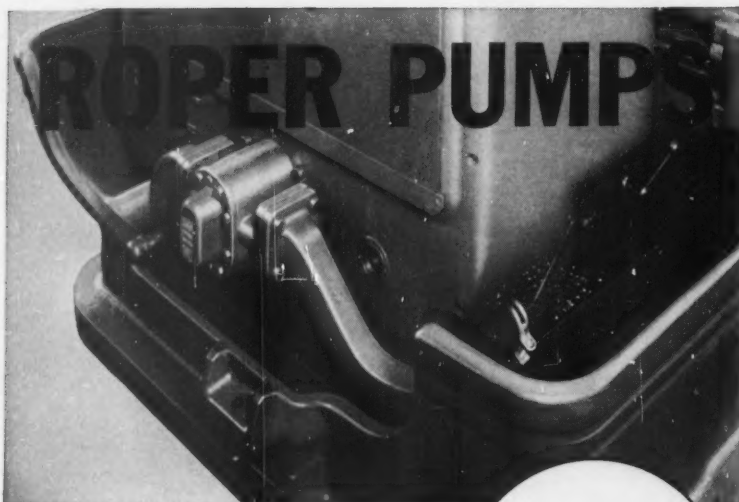
High quality Meehanite mandrels reduce tooling costs by combining dimensional accuracy, high strength, fine surface finish and long service life.

For more information, send for your free copy of our new brochure on Meehanite Mandrels. Write to Meehanite Metal Corporation, 714 North Avenue, New Rochelle, New York.

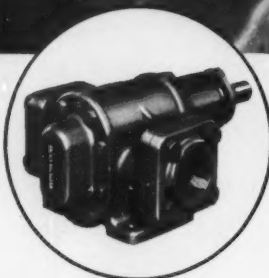


MEEHANITE METAL

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES.



SERIES K adapted to the demands of a wide range of jobs



3/4-50 GPM • PRESSURES TO 150 PSI • SPEEDS TO 1740 RPM

Typical of the great adaptability of the compact Roper Series K rotary pump is its service as a coolant pump in supplying soluble and cutting oils to this automatic screw machine. The requirement for instant priming in this machine requires a positive displacement pump. The rugged Series K meets the specifications of many original equipment manufacturers who require dependable, quiet, efficient transfer of clean liquids in hydraulic service, fuel supply duty for large oil burners, or diesel fuel oil transfer. Special fittings for transfer of corrosive liquids and special mountings to meet installation requirements can be supplied. Series K models can be direct connected, chain-, belt-, or gear-driven. Precision construction and thorough individual pre-testing insure its durability of performance. Specify Roper for rugged dependability.

Features behind Series K versatility

● Simplified design... only two moving parts ● Smooth flow... quiet operation ● Interchangeable mounting brackets... easy to install ● Precision-built... requires little operating power ● Self-priming... high suction lift... correct hydraulic principle ● Built-in relief valve... adjustable or pre-set.

*For information about your specific pump needs,
contact your nearest Roper dealer*

Send for "How to Solve Pumping Problems" booklet

ROPER
HYDRAULICS, INC.

**Dependable pumps
since 1857**

COMMERCE, GEORGIA

HELPFUL LITERATURE

Limit Switch

Bulletin GEA-7305 describes magnet-operated limit switch for highly accurate position detection, without physical contact, of objects moving in erratic paths. Text explains why no arms, levers, rods, shafts, or slots are necessary with the unit, and drawings show proper method of operation and mounting. Encapsulated construction, wide mounting flexibility, excellent repetitive accuracy, and application versatility are also featured. 4 pages. General Electric Co., Schenectady 5, N. Y.

Circle 637 on Page 19

Flexible Hose

General Data Bulletin 605 covers flexible hose and duct, providing selection and installation information. Many applications are shown in drawings and photographs. Information on materials available is also included. 12 pages. Flex-aust Co., 100 Park Ave., New York 17, N. Y.

Circle 638 on Page 19

Dials and Accessories

Compiled in Revised Catalog 9 are data on a series of dials and accessories most widely used when designing, experimenting, and producing mechanisms. Large drawings are provided of all units, and line drawings and charts furnish size data. Included are stock dials, ring dials, drum dials, verniers, knobs, and hubs. 40 pages. Ackerman Engravers Inc., 458 Broadway, New York 13, N. Y.

Circle 639 on Page 19

Pushbutton Switches

Data Sheet 182 covers in detail Series 302PB1-T miniaturized, lighted pushbutton switches. Sheet includes details of construction, electrical ratings, pricing and ordering information, as well as photographs and dimensional drawings. 2 pages. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 640 on Page 19

Plastic-Enclosed Relays

Engineering Bulletin 1010 describes new plastic-enclosed, Model DOS relays, general-purpose units with contacts and terminals mounted in molded phenolic parts. Physical and mechanical data on new dust enclosure are provided on one side of the bulletin, and information on the complete line of relays is presented on the opposite side. 2 pages. Ohmite Mfg. Co., 3630 Howard St., Skokie, Ill.

Circle 641 on Page 19

Universal Motors

Bulletin 3100 provides pictures, line drawings, dimensions, and construction specifications for seven models of motors. Availabilities list is provided, as well as information on a base mounting. List of applications is also included. 6 pages. Motor Specialty Inc., 2801 Lathrop Ave., Racine, Wis.

Circle 642 on Page 19

Automotive, Industrial Joints

Extensive Catalog J-1960 provides information on automotive and industrial universal joints. Wide range of general engineering data on universal joints is provided. Catalog gives descriptive information and complete joint specifications for all units available. Servicing instructions and ordering information are given. Line drawings and tables provide dimensional data. 220 pages. Mechanics Universal Joint Div., Borg-Warner Corp., 2020 Harrison Ave., Rockford, Ill.

Circle 643 on Page 19

Trimmer Potentiometer

Type SW $\frac{1}{2}$ subminiature square trimmer is described in new bulletin. All data are provided in photographs, line drawings, and a graph. Six nonstandard, special trimmers are also shown and briefly described. 2 pages. Technology Instrument Corp. of Illinois, 10130 W. Pacific Ave., Franklin Park, Ill.

Circle 644 on Page 19

Alloy Steel Castings

Catalog titled "Custom Alloy Steel Castings," 175 DS, contains technical data regarding heat, corrosion, and abrasion-resistant alloy steels. Charts list nearly half of the more than 100 available cast alloys. 24 pages. Esco Corp., 2141 N.W. 25th Ave., Portland 10, Oreg.

Circle 645 on Page 19

Metering System

Specification 10D1410B describes a metering system consisting of a magnetic flowmeter, standard or miniature type, and an indicator-recorder which measures fluids with low conductivities. Information is given on the materials of construction, mounting, and capacities of the primary element, on the secondary read-out, and on dimensional drawings and wiring diagrams for the system. 8 pages. Fischer & Porter Co., 743 Jacksonville Rd., Warminster, Pa.

Circle 646 on Page 19

Electron Tubes

New condensed tube catalog contains descriptions and basic specifications on a full line of tubes. Type numbers of the various units are listed in tables, and a description of each is provided, along with notation of its applications. 25 pages. Write on company letterhead to Ampere Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Centrifugal Pumps

Circular 184 is a selection catalog for users of centrifugal pumps. Included in the circular are charts showing the recommended temperature and pressure ranges for ten classifications of pumps, from -350 to +1000 F, and up to 1000 psig. Illustrations, brief descriptions, and specifications are shown for each. Write on company letterhead to Dean Brothers Pumps Inc., 323 W. 10th St., Indianapolis 7, Ind.



ABRASION RESISTANCE

A CASE IN POINT—Under highly abrasive conditions dust and fly ash collector tubes such as these used to give out in less than a year. Ni-Hard castings were an obvious yet difficult answer because the 38" length with $\frac{5}{16}$ " section was hard to cast. Where others failed Hamilton Foundry succeeded in casting these in production quantities for Western Precipitation Multiclones. The hardness (up to 700 Brinell) and metallurgical structure of Ni-Hard make it one of the most abrasion resistant materials commercially available today. Tubes from Hamilton Foundry Ni-Hard now last more than five times as long as before.

When buying castings, the skill and integrity of Hamilton Foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (MODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD



HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWInbrook 5-7491

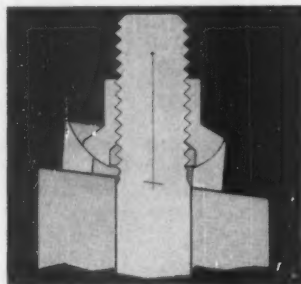
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Self-Aligning Lock Nut

swivels within seat
of alignment washer

SA16 self-aligning lock nut develops full rated strength of aircraft bolts even though seating surface is as much as 8 deg out of perpendicular to the shank. Fastener consists of a hex-drive self-locking nut which swivels within the spherical seat of a precision alignment washer. Constant bearing area between alignment washer and nut from 0 to 8



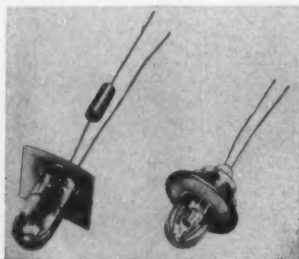
deg is maintained, permitting full rated strength of 160,000 psi to be utilized at all angles. Both components of the fastener are alloy steel, operational to 550 F. Nuts are available in diameter sizes No. 10 through $\frac{3}{8}$ in., in Class 3B National coarse and fine-thread series. They are supplied either cadmium plated or with the addition of a dry-film lubricant. **Standard Pressed Steel Co., Jenkintown, Pa.**

Circle 647 on Page 19

Indicator Assemblies

operate on standard
line voltage

Econoglo neon-glow indicator assemblies are simple, inexpensive units. Operating on standard line voltage, they are supplied in two styles, one with a Tinnerman nut, the other with a snap-in plug. Both mount from the front of panel, and



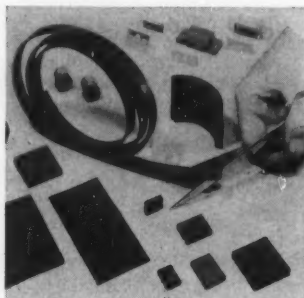
both are available with or without built-in current-limiting resistors. Plain, fluted, or flat-cap lens styles are available in colorless, red, yellow, or white. High-brightness neon-glow lamps burn out at the end of useful life so that units can be kept at maximum visual effectiveness. Applications include radio, television, communications equipment, instruments and automation, office machines and computers, portable appliances, toys and novelties. **Drake Mfg. Co., 4626 N. Olcott Ave., Chicago 31, Ill.**

Circle 648 on Page 19

Permanent-Magnet Material

is easily cut or shaped

Low-cost, lightweight, permanent-magnet material, Plastiform I, has excellent magnetic qualities, comparable to sintered isotropic barium ferrite. Neither hard nor brittle, it can be machined or cut easily. Impact strength is high, and it will



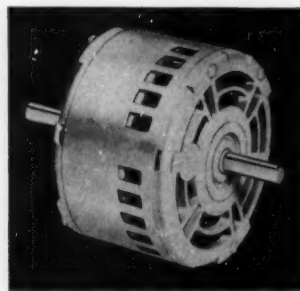
not chip in use. Applications include magnetic cabinet latches, holding devices, toys and novelties, dc motors, and gasket inserts. Material is furnished in many forms, such as rings, sheets, and strips. **Leyman Corp., 5178 Crookshank Rd., Cincinnati 38, Ohio.**

Circle 649 on Page 19

Fractional-Horsepower Motors

in ratings from 1/15
to $\frac{1}{2}$ hp at 1050 rpm

New split-capacitor, fractional-horsepower motors provide high efficiency and quiet operation even where heat is a problem. Available in ratings from 1/15 to $\frac{1}{2}$ hp at 1050 rpm (115 v, 60 cycles), units can also be wound for 208 or 230-v operation at 50 or 60 cycles. Features include full skew, centrifu-



gally cast rotors with distributed wound stators; large, $\frac{1}{2}$ -in. bearings; moisture-proof slot and cell insulators; precision-ground and polished shafts. All motors meet UL and CSA application tests. **Leece-Neville Co., 989 Athens St., Gainesville, Ga.**

Circle 650 on Page 19

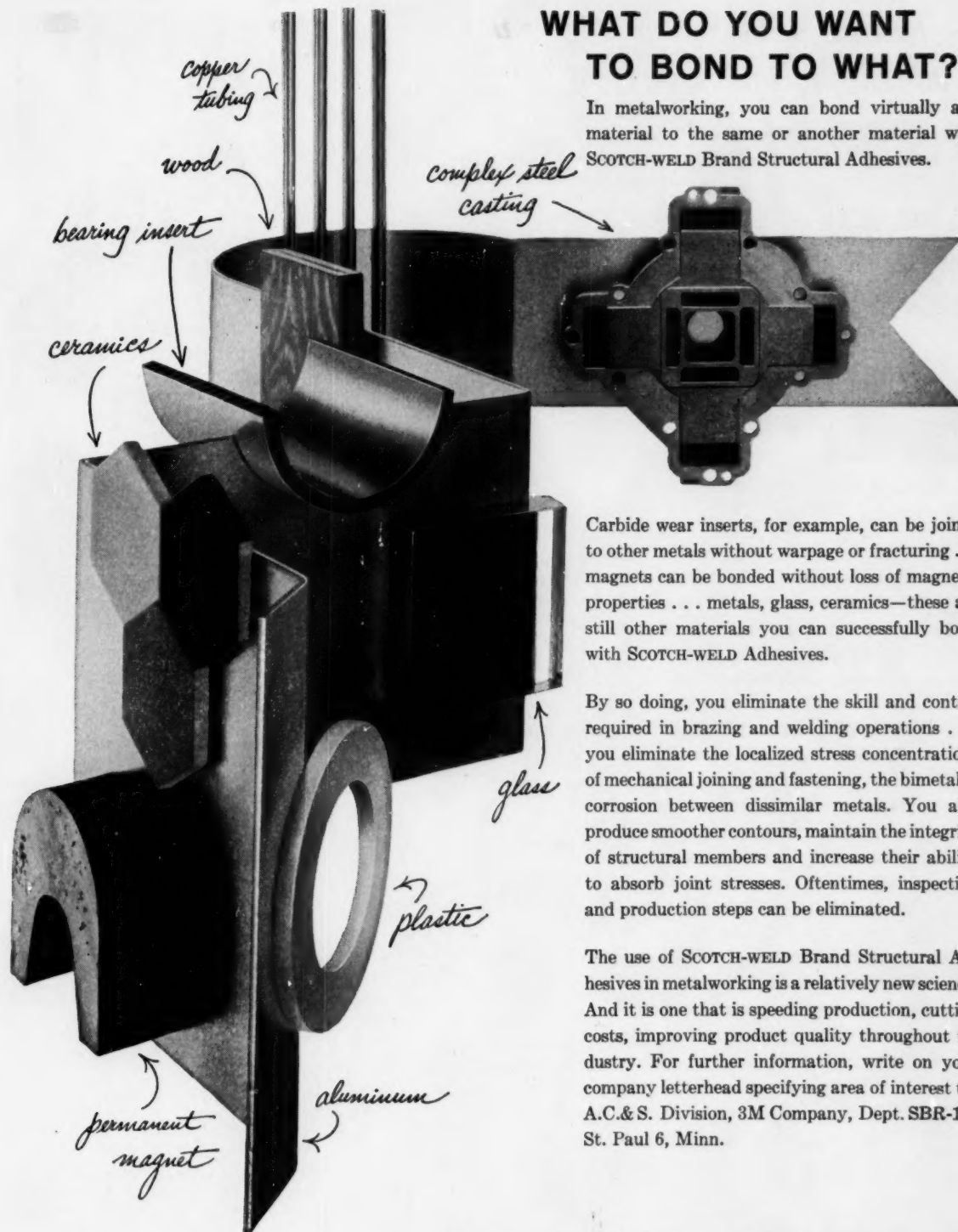
Miniature Filter Chambers

have clear shell for
viewing of filtration

Miniature filter chambers handle small volumes of corrosive chemi-

WHAT DO YOU WANT TO BOND TO WHAT?

In metalworking, you can bond virtually any material to the same or another material with SCOTCH-WELD Brand Structural Adhesives.



Carbide wear inserts, for example, can be joined to other metals without warpage or fracturing . . . magnets can be bonded without loss of magnetic properties . . . metals, glass, ceramics—these are still other materials you can successfully bond with SCOTCH-WELD Adhesives.

By so doing, you eliminate the skill and control required in brazing and welding operations . . . you eliminate the localized stress concentrations of mechanical joining and fastening, the bimetallic corrosion between dissimilar metals. You also produce smoother contours, maintain the integrity of structural members and increase their ability to absorb joint stresses. Oftentimes, inspection and production steps can be eliminated.

The use of SCOTCH-WELD Brand Structural Adhesives in metalworking is a relatively new science. And it is one that is speeding production, cutting costs, improving product quality throughout industry. For further information, write on your company letterhead specifying area of interest to: A.C.&S. Division, 3M Company, Dept. SBR-11, St. Paul 6, Minn.

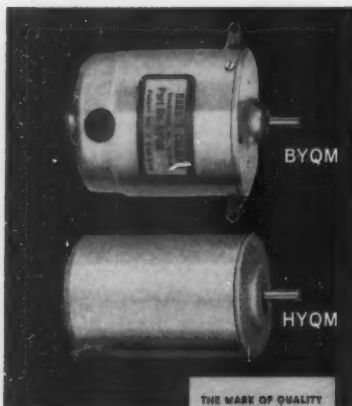
ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

... WHERE RESEARCH IS THE KEY TO TOMORROW



Barber-Colman battery-operated d-c motors with integral governors



ideal for many of
today's portable
applications

Type BYQM, top, is inexpensive, yet of excellent quality to meet consumer demand for dependability in mass-produced goods. Type HYQM is an exceptionally fine-quality battery-operated motor for the more demanding applications such as portable dictating equipment.

BYQM-Typical Specifications

Voltage range..... approx. 3 to 30
Governed speed..... 1200 to 6000 rpm
Torque..... 0 to .20 oz-in.
Diameter..... 1.29"

HYQM-Typical Specifications

Voltage range..... 4.5 to 30 volts
Governed speed..... 1500 to 5000 rpm
Torque..... 0 to .20 oz-in.
Diameter..... 1"

TYPICAL APPLICATIONS

PORTABLE DICTATING MACHINES
PHOTOGRAPHIC EQUIPMENT
DRIVE MECHANISMS
TAPE PLAYERS
ROTATING BEACONS
DEPTH FINDERS
BLOWERS
PORTABLE INSTRUMENTS
ROTISERIES

WRITE FOR HELPFUL DATA SHEETS on
BYQM and HYQM battery-operated motors
specifically designed to fit individual cus-
tomer applications.

BARBER-COLMAN COMPANY
DEPT. M, 1873 ROCK STREET, ROCKFORD, ILLINOIS

Circle 502 on Page 19

NEW PARTS AND MATERIALS

cals and solvents. Available in Lucite, epoxy, PVC, and Teflon, chambers are 5 in. high and 2 in. in diam, weigh approximately 8 oz, and have a filtering capacity of 5 to 7.5 gph. Filtration can be viewed through clear Lucite or Pyrex shell of the chamber. Filter tubes are cotton, Dynel, porous stone, and carbon, depending upon



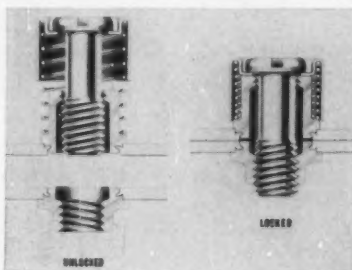
application, for filtering from 1 to 150 microns. All chambers are furnished with a threaded, stainless-steel, type-316 center rod which extends through the base of the chamber. Stainless-steel air vent is provided on the top plate for bleeding air out of the chamber during filtration as well as for draining the last drop of liquid before disassembly. Sethco Mfg. Corp., 2284 Babylon Turnpike, Merrick, L. I., N. Y.

Circle 651 on Page 19

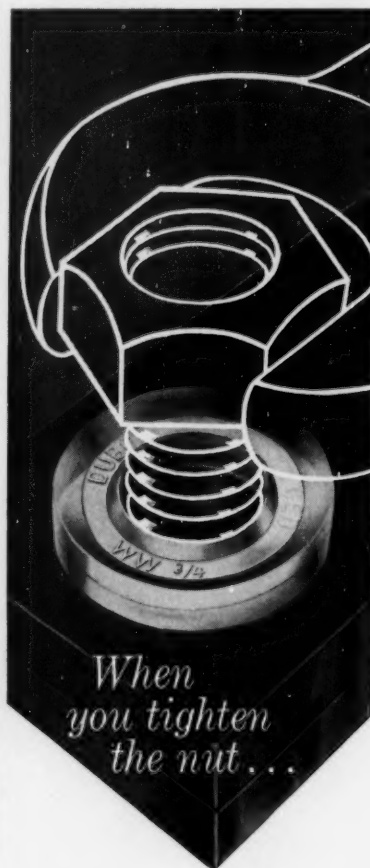
Panel Fastener

for removable
panel applications

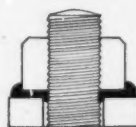
P-Series panel fastener is simply installed. Only a single hole is needed to accept press-in type retainer, readily installed with hand or power tools. Developed for removable panel applications, fastener can be used in combination with NAS576 self-locking nuts, press-in nuts, or in tapped holes. Because of its float-



This new lock and seal washer
is just plain **REVOLUTIONARY...**



NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it... so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one in incorrectly if you tried.

PLUS FEATURES: excellent electrical properties... exceptional wear resistance... good shock absorption... resists corrosion, chemicals... non-flammable... high flexural strength.

PLUS USES: The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

YOU'LL WANT COMPLETE TECHNICAL INFORMATION.

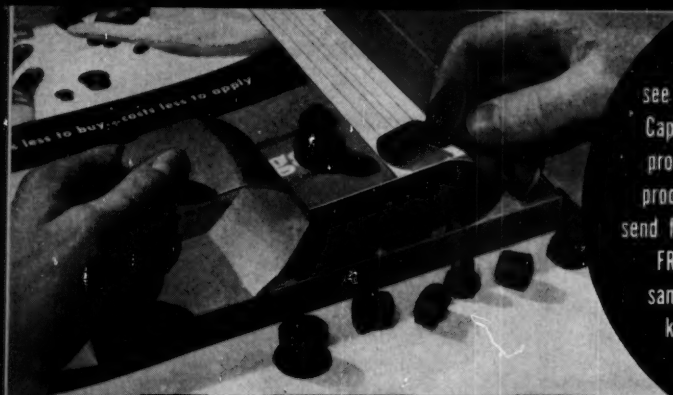
Write today to:



NYLOGRIP PRODUCTS

569 Pleasant St., Watertown, Mass.-WA 6-0100
Non Metallic Fastenings of all types.

Circle 503 on Page 19



see how
Caplugs
protect
products...
send for this
FREE
sample
kit

CAPPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2201 Elmwood Ave., Buffalo 23, N. Y.

MAIL a free assortment of Caplugs, literature and prices to us,
without obligation.

Name

Title

Firm

Address

City Zone State

Circle 504 on Page 19

won't chip, break,
shred, or collapse

low cost
product insurance

easy to apply...
and remove

molded of tough,
flexible Polyethylene

Caplugs

Quick, slick protection for
tubing, threaded fittings and machined parts
in process, storage and transit...
more than 600 sizes now in stock



DELRIN* and LEXAN®

**ROD and
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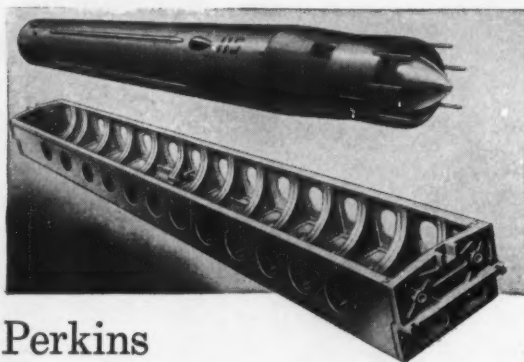
Member of Plastic Pioneers

*Du Pont Trademark
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Circle 505 on Page 19

Missile tray made by Brooks & Perkins *beats target weight by 300 lbs.*



Air transported missiles require minimum weight handling equipment so that important defense weapons can be moved efficiently and on schedule. Recently, Brooks & Perkins was given the responsibility for engineering, designing, building the prototype and manufacturing an aluminum missile tray, shown above.

Unusual loading problems and the extreme importance of deflection required a dimensional tolerance of $\pm \frac{1}{32}$ " in the 33-foot over-all length at 68°F. B & P not only met all tolerance requirements, but also reduced the initial target weight by 300 lbs.

The aluminum missile tray is another example of Brooks & Perkins skill and experience in the fabrication of light metal products for ground support equipment.

For more information and details of this and other GSE programs, write direct to Brooks & Perkins, Detroit.



BROOKS & PERKINS, Inc.

1940 W. FORT ST., DETROIT 16, MICH.

Offices in Washington and New York

60-T-1

Circle 506 on Page 19

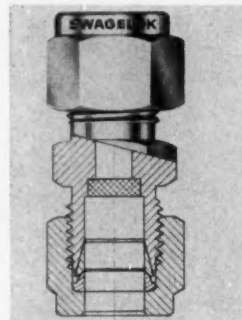
NEW PARTS AND MATERIALS

ing feature, bolt portion of assembly easily accommodates misaligned holes. Bolt is spring-loaded, allowing bolt threads to be retracted fully and protected when fastener assembly is not engaged. Fasteners are available in single or double-lead threads and in thread sizes from No. 4-40NC-3B to No. $\frac{1}{4}$ -28UNF. Basic fasteners are initially available in alloy steel and titanium configuration. **Hi-Shear Corp.**, 2600 W. 247th St., Torrance, Calif.

Circle 652 on Page 19

Snubber Tube Fitting

in sizes for $\frac{1}{8}$
through $\frac{3}{8}$ -in. OD tubing



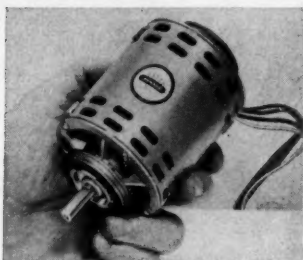
Use of Swagelok snubber tube fitting prevents damage to costly equipment from sudden flow surges. Fitting provides a dampening effect and protects gages and other instruments from injurious effects caused by pulsating pressures. It serves as a filtering device for liquids and gases, especially in low-flow lines. Fittings are available in all standard tube-fitting shapes. Snubber is available with Type-316 stainless or bronze sintered elements. Elements are readily removable for easy maintenance or replacement. Fittings, with snubber, are available in a variety of materials in sizes from $\frac{1}{8}$ through $\frac{3}{8}$ -in. OD tubing. **Crawford Fitting Co.**, 884 E. 140th St., Cleveland 10, Ohio.

Circle 653 on Page 19

Induction Motor

incorporates 24-slot stator

Twenty-Six Frame fractional-horsepower electric motor is a 3-in. induction unit for office machines and similar uses. Designed with 24-slot



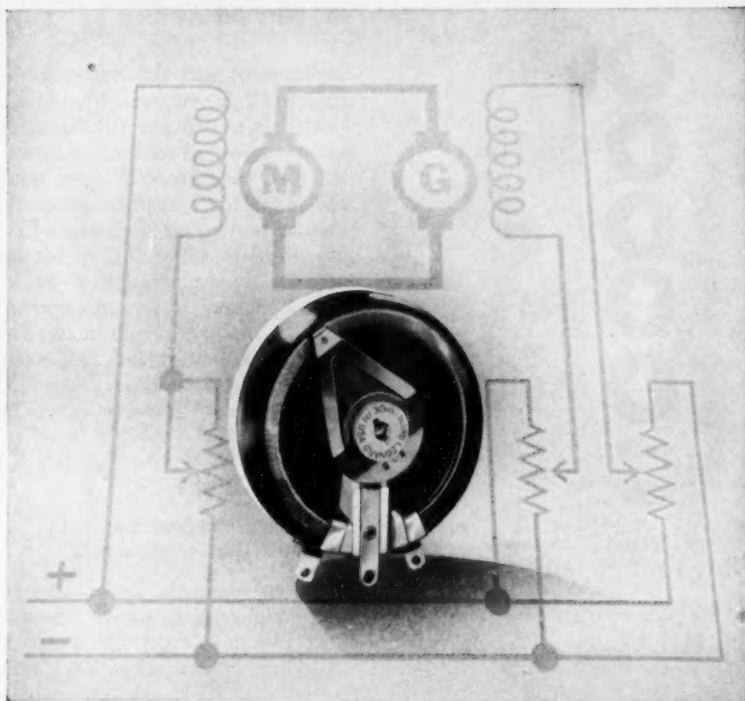
stator, motor achieves smooth, constant torque and quietness. Design of housing and end parts provides accurate bearing alignment plus uniform air gap between stator and rotor. Porous-bronze or ball bearings are available, and steel shaft is $\frac{1}{2}$ in. in diam. Effective heat transfer is achieved by a press fit between frame and stator, and Mylar plastic insulation cuts down the chances of internal grounding and is more resistant to moisture. Fabricated rotor is pressure-cast of virgin aluminum to insure a uniform squirrel cage. Three types of mountings are available: Low-cost spring-wire mounting with a compounded-rubber shock absorber; standard foot mounting; or face mountings. Four-pole ratings are available in ratings to 1/20 hp; two-pole units are furnished in ratings to 1/10 hp. The 3-in. diam is constant, and length varies from 3 $\frac{11}{16}$ to 5 $\frac{7}{16}$ in. **Howard Industries Inc., 1760 State St., Dept. 31, Racine, Wis.**

Circle 654 on Page 19

Compressor, Vacuum Pump

is 1/12-hp, miniature unit

Because of miniature size and quiet operation requiring no lubrication maintenance, new miniature compressor and vacuum pump is suited to a wide range of industrial, laboratory, and office uses. The 1/12-hp unit is furnished in two models: Model LV, which has a 1.9 cfm



Background is schematic of world-famous Ward Leonard system of control.

In modern rheostat circuits, it's SERVICE CONTINUITY THAT COUNTS

Production stopped. Workers idle. But wages, maintenance costs, and fixed charges go merrily on accumulating.

That's the black picture when an industrial control component—specifically a rheostat—fails. That's why reliability is more important than initial cost. In many cases, these irrecoverable charges and costs can quickly far exceed the replacement cost of the faulty components.

And that's why far-sighted designers are more and more specifying Ward Leonard VITROHM ring rheostats for control circuits where performance is a must...in motor and generator field control circuits...for electronic tube filament circuits...wherever substantial amounts of power must be handled with utmost rheostat reliability.

Ward Leonard ring rheostats, in sizes of 25, 50, 100, 150 and 300 watts, feature W/L's exclusive "twin contact shoe" design. Two sintered, self-lubricating contact shoes minimize wear and assure uniform contact pressure, smooth operation,

and maximum reliability.

Special alloy resistance wire—made to W/L's closely monitored specifications to assure highest stability and lowest practical temperature coefficient—is bonded permanently to ceramic core by Ward Leonard's own VITROHM vitreous enamel.

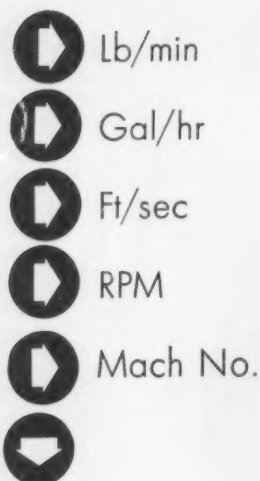
These are just a few of the reasons why VITROHM ring rheostats give you outstanding reliability in industrial control circuits. There are many more quality-engineered features than we can describe here—for instance, highest grade ceramic base and core, durably bonded tinned alloy terminals, and balanced beryllium copper contact arm. You'll find them all in Bulletin 60RR (and for powers above 300 watts, check W/L plate rheostats in Bulletin 60A). For your copy, and for a list of stocking distributors, write: Ward Leonard Electric Co., 58 South St., Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)

C.S.



**WARD LEONARD
ELECTRIC CO.** MOUNT VERNON
NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS



Now you can read them all...
directly, instantly with
Erie Instru/mation Model 740
Frequency Counter and
Preset Translator



Model 740 is designed for monitoring any frequency to 120,000 cps and converting directly to physical units using standard transducers. One example is in flow calibration systems for engines or turbines where lb/sec or gal/min of flow is a requirement. Rate measurement applications include Flow, linear velocity and production monitoring (articles or volume per unit time). Physical units of interest (e.g. lbs/hr) are displayed with in-line NIXIE readout. The Model 740 can also be used as a preset time interval generator and periodic or random event counter.

Modular construction, manual or automatic recycling and fine increment time base selection are other quality features that make the 740 an outstanding instrument. Write for complete technical information to:



ERIE PACIFIC, DIVISION OF
ERIE RESISTOR CORPORATION

12932 S. Weber Way
Hawthorne, California

Circle 508 on Page 19

NEW PARTS AND MATERIALS

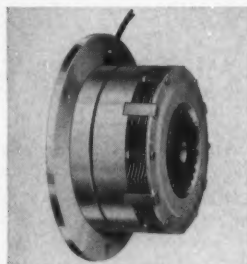
displacement and operates continuously to 27 in. vacuum; Model LC, which has a 1.43 cfm displacement and is capable of continuous operation to a pressure of 65 psig. Both models include a built-in automatic overload-prevention mechanism that also prevents motor failure in the event of abnormal electrical conditions. Weighing 18 lb, units operate at 1725 rpm with split-phase, induction-type motors. **Bell & Gossett Co.**, Morton Grove, Ill.

Circle 655 on Page 19

Magnetic Brake

in short, compact size
provides fast engagement

SA electromagnetic brake has an exceptionally high torque vs. size ratio. Design is short and compact, and friction plates are isolated from the magnetic field, permitting high torque capacity and precise control. Engagement is extremely fast, yet



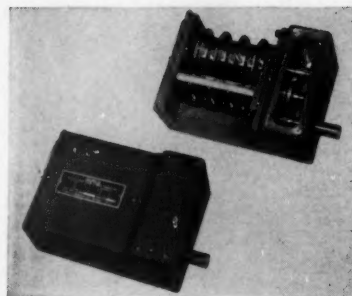
smooth and shock-free. Unit has excellent heat-dissipation characteristics, and torque is not affected by speed of engagement. Twelve standard sizes range in diameter from 2.25 to 11.5 in., with torque ratings from 35 to 32,500 lb-in. **Fawick Airflex Div., Fawick Corp.**, 9919 Clinton Rd., Cleveland 11, Ohio.

Circle 656 on Page 19

Limit Switch

has built-in gear reducer

Ten gear ratios are offered as standard in rotating-cam limit switch. Ratios range from 2:1 to 400:1. Gear reducer with a 3/4-in. shaft extension and keyway adds only 3 in. to over-all length of standard 1:1 switch. Compact unit eliminates coupling and plate where reducer and switch are mounted separately. Switches are available in NEMA



types 1, 4, 7, 9, and 12 enclosures with from 1 to 24 circuits. Completely adjustable cam lobe provides an adjustment range from 8 through 360 deg and eliminates special cams. Single-pole, double-throw, snap-action switches are offered as standard and have one normally open and one normally closed contact which are electrically separate. Switches are rated at 5 amp, 600 v ac; 6 amp, 440 v ac; 10 amp, 220 v ac; and 15 amp, 115 v ac. **Gemco Electric Co.**, 25685 W. Eight Mile Rd., Detroit 40, Mich.

Circle 657 on Page 19

Miniature Stake Nuts

in floating and
nonfloating types

Minimum thickness requirements for miniature floating and nonfloating stake nuts are 0.040 and 0.030 in. respectively, making possible the reduction of parent material thicknesses. Application of the stake nuts provides maximum installed reliability of threaded elements in thin-section materials. Push-out, torque-out, and thread-locking features exceed all requirements of MIL-N-25027. Installation requires only a single hole which can be punched or drilled. Design at base of nut provides a positive stop when driven into the parent material. Self-staking operation provides cold flow of the parent material so that an interlock is created between parent material and part. Visual, positive means of determining when instal-



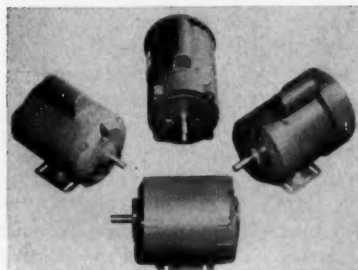
lation depth has been achieved is provided. Kaylock Div., Kaynar Mfg. Co. Inc., Box 2001 Terminal Annex, Los Angeles 54, Calif.

Circle 658 on Page 19

AC Motors

**fractional-horsepower units
are for industrial duty**

Fractional-horsepower ac motors, called Duty Master, are available in eight horsepower ratings from 1/20 to 3/4 hp. Capacitor-start, split-phase, and polyphase units are made in frame sizes 48 and 56; repulsion-start, induction-run models are furnished in frame size 56. Open protected, totally-enclosed fan-cooled; totally-enclosed, nonventilated, and explosionproof enclosures



can be specified. Engineered for industrial duty, units feature a rolled-steel frame with high-strength, cast-aluminum alloy end shields. Ball or sleeve bearings can be specified. Ball bearings are double-shielded and permanently lubricated. Sleeve bearings are packed with Perma-wick that soaks up and combines with oil. Duty Master sleeve bearing motors may be mounted either vertically or horizontally with moderate end thrusts. Built-in thermal protectors operate in the event of excessive motor temperature or excessive current input. Mounting is provided for either manual or automatic reset types. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.

Circle 659 on Page 19

Hydraulic Accumulator

in sizes from 1 pt to 2 1/2 gal

Three functions are performed by oil-hydraulic accumulator: That of a power-storage chamber so that a low-volume pump can supply a

OUTSTANDING

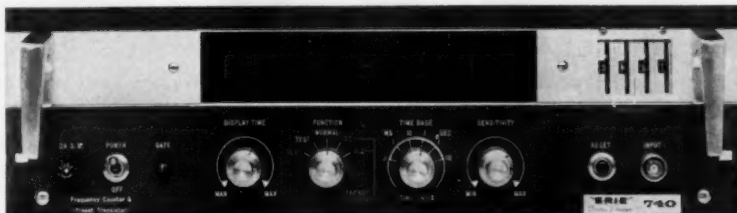
ERIE INSTRU/MATION

700 SERIES COUNTER-TIMERS

Here is a beautifully designed line of compact instruments of unusually high quality, performance and dependability for use in laboratories, original equipment and production lines where accurate measurement of events-per-unit time, period, or elapsed time is important. Operator-designed panels and in-line NIXIE readout assure positive, direct reading. Modular construction gives great flexibility and ease of maintenance and makes these instruments the most compact of any on the market. If you are looking for reliability, versatility and quality combined with reasonable price, the ERIE INSTRU/MATION 700 series of counter-timers deserves your serious consideration. Write for complete catalog to:



Model 740
**FREQUENCY COUNTER &
PRESET TRANSLATOR**
for direct conversion from
frequency to physical units



Model 720
FREQUENCY COUNTER
for events-per-unit time



Model 722
FREQUENCY-PERIOD COUNTER
combines frequency & period measurement



Model 723
TIME-INTERVAL COUNTER
for measurement of
elapsed time between events



Model 724
PRESET RATIO COUNTER
1 to 10,000 times ratio of two input signals



Model 725
UNIVERSAL COUNTER-TIMER
precise measurement of
frequency, period and time intervals



ERIE PACIFIC, DIVISION OF ERIE RESISTOR CORPORATION

12932 S. Weber Way, Hawthorne, California

Snap-ring grooves in this 12" O. D. thin-section *Reduction Drive Gear* are machined before carborizing and hardening. Both spline and gear teeth are ground and held to .001" excentricity after hardening the entire gear.

When you
DRIVE
for profits,
GEAR
with



PERKINS

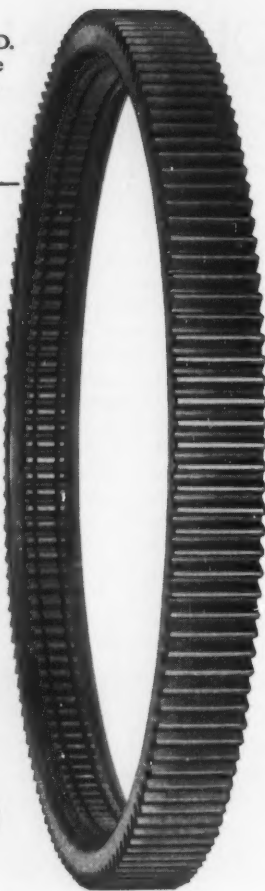
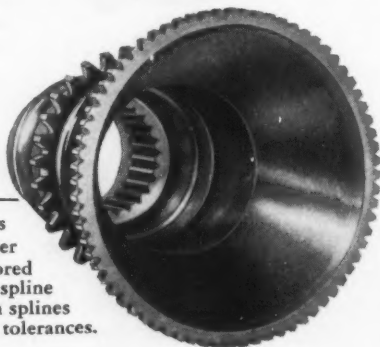
MACHINE AND GEAR CO.

Dept. 83 West Springfield, Mass.

This Handy Gear Calculator, easy to use, saves time. Folder illustrating Perkins custom precision gears and facilities offers information. Both yours on request.

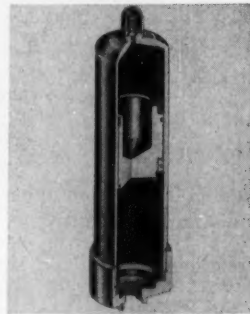


Most machining operations on this *Drive Gear Shaft* are performed after localized hardening with the cored areas at Rockwell C42. External spline and gear teeth are ground with splines held to precision tolerances.



Men who *know* will tell you that custom precision gears made by Perkins can eliminate many design, production and maintenance headaches — literally help you drive for better profits. When you want precision gears in experimental or production quantities, chances are you'll save time and money by checking with Perkins first. What is your gear problem today?

NEW PARTS AND MATERIALS



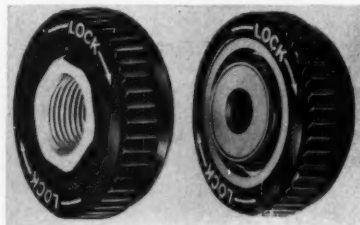
large amount of energy for a brief moment; that of a pressure compensator to maintain system pressure so holding cylinders do not lose their grip; to eliminate surges and vibration, smooth out pressure pulses, and prevent shock from fast-closing valves. Weldless steel outer shell is made in one piece by spin-forging. Hollow aluminum piston is statically balanced, and includes double Quad-Ring seals. It is proportioned to dispense a maximum amount of fluid with a minimum gas charge and no danger of pressure lock. Connection to a hydraulic circuit is made at a pipe-threaded opening at one end. Hydraulic pressure on this side of the floating piston is made compressible by a charge of nitrogen gas on the other side. Gas is introduced through a valve covered by a protective cap. Six models are offered for 3000-psi service, and four for 3500-psi service. Stock size ranges from 1 pt to 2½ gal over-all. Crescent Hydraulic Co., 1303 Otsego Rd., Allegan, Mich.

Circle 660 on Page 19

Control-Knob Lock

has rubber insert to prevent water leakage

Splashproof, dustproof control-knob lock is designed for exterior use with potentiometers and other variable controls. Water leakage is prevented around control shafts by

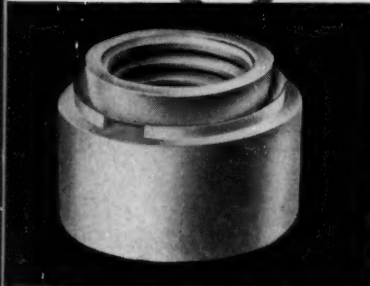


Circle 511 on Page 19→

PEM

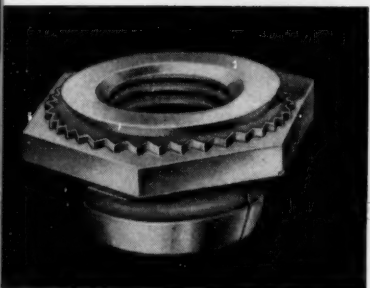
CAPTIVE THREADS for Production Fastening...

THE ORIGINAL SELF-CLINCHING FASTENER



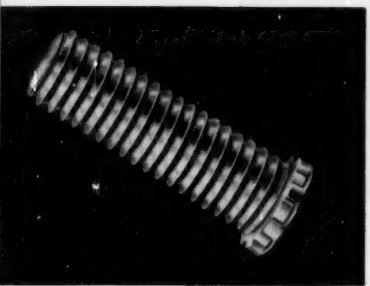
Made in steel, stainless steel, aluminum and Monel. Positively locked into prepared holes by any standard squeezing tool. For metal thicknesses down to .032". Sizes from No. 0 to 3/4". Bulletin CL.

SELF-CLINCHING, SELF-LOCKING NUT



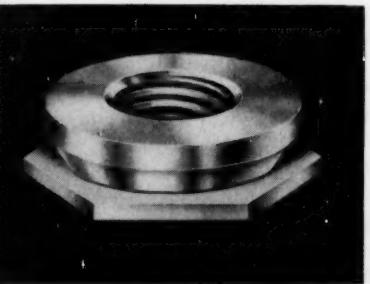
All metal (steel, stainless steel or aluminum) combines 2 functions in single light-weight, low-cost unit for sheet metal fastening. Suitable for installation in sheet thicknesses from .040" and up. Sizes from No. 2 to 10. Bulletin SL.

SELF-CLINCHING CAPTIVE STUD



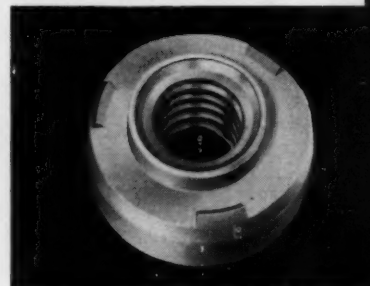
Steel and stainless steel, designed for quick, easy flush-head installation in panels of cold-rolled steel, brass, copper, aluminum alloys and similar materials. Sizes No. 4 to 3/8". Lengths from 1/4" to 1 1/2". Bulletin FH.

SELF-CLINCHING FLUSH FASTENER



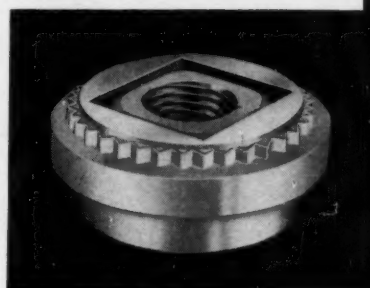
One-piece, stainless steel threaded insert installs in sheet thicknesses from .061" and up with flush mounting area on both sides of sheet. Suitable for materials with Rockwell Hardness of B-70 and less. Sizes No. 2 to 1/4". Bulletin FH.

SELF-LOCATING WELD FASTENER



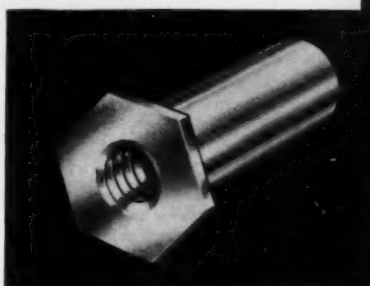
Steel and non-magnetic stainless steel. Nut is projection welded to part with extended shank protecting threads from weld splatter and serving as pilot in assembly. No. 2 to 1/4". Bulletin WN.

SELF-CLINCHING FLOATING NUT



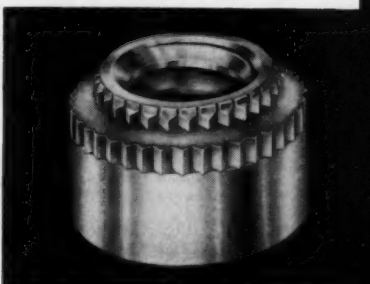
Carbon steel and stainless steel. Provides rapidly assembled nut anchor in sheet metal and compensates for slight errors (up to 1/8") in alignment of mating holes. Sizes No. 2 to 1/4". Suitable for sheet thicknesses from .040" up. Types AS and AC.

SELF-CLINCHING STAND-OFFS



Made in both blind and threaded-through types in steel, aluminum and stainless steel. Sizes No. 4 and No. 6. Overall lengths from 1/8" to 1 1/8". Suitable for use in sheet thicknesses from .040" and up. Bulletin SO.

SELF-CLINCHING SPLINE FASTENER



For hard metals and brittle materials — magnesium, glass laminates, epoxies, etc. Made in steel and stainless steel. Sizes No. 2 to 3/8". Type KF.

PENN ENGINEERING & MANUFACTURING CORP.

DOYLESTOWN • PENNSYLVANIA

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Assembly Problem? Clamp with HY-GEAR!



If the fastener you now use in your product risks corrosive attack, cannot be reused, costs too much to install, is not strong enough, undermines the effectiveness of your product—consider the versatility and economy of Hy-Gear worm drive clamps. Band and housing are premium stainless steel. Hy-Gear—available with either stainless steel or cadmium plated worm screw—installs easily, has a powerful grip—can be used over and over again.

Available in Three Styles

Safety-collared type is recommended when Hy-Gear is installed in confined areas... Collar prevents slipping of screw-driver—speeds tightening.



Non-collared economy type serves equally well when area of application is not restricted by space limitations. Has deep slotted screw for easy screw-driver tightening.



Thumb-screw type to enable hand tightening on laboratory apparatus, appliances and other equipment where frequent tightening and untightening is required.



For a sample of the style Hy-Gear that interests you...or a catalog covering Hy-Gear and other Ideal clamps, write

IDEAL CORPORATION
427 Liberty Avenue
Brooklyn 7, N.Y.



**Headquarters
for clamps
since 1913**



Circle 512 on Page 19

NEW PARTS AND MATERIALS

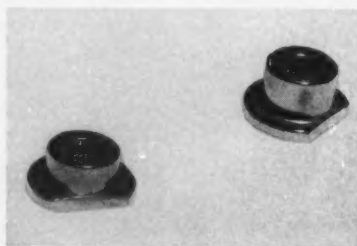
a special rubber insert molded over the threaded-metal bushing of the knob lock. Lock is mounted directly on the threaded bushing of the control. A one-eighth turn of the fluted skirt firmly locks the control without disturbing critical control settings. Built to military specifications, units meet standard shock, vibration, salt spray, and humidity tests. **Industrial Components Div., Raytheon Co., 55 Chapel St., Newton 58, Mass.**

Circle 661 on Page 19

Component-Mounting Cleats

accommodate all Mark or BuOrd Series rotating components

Expanded line of precision component-mounting cleats insures precision placement of motors, synchros, resolvers, and potentiometers. Sized to accommodate all Mark, or Bureau of Ordnance Series rotating



components, cleats are machined from No. 303 stainless-steel bar or cast with No. 416 heat-treated stainless steel. Clear, passivated finish is provided on both types. **PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.**

Circle 662 on Page 19

Trimming Potentiometers

have resistance range of 10 to 50,000 ohms

Two Circuitrim subminiature precision trimming potentiometers are available for printed-circuit and other high-stability applications. One unit, type CT-100 (shown), offers economy as well as excellent mechanical and electrical characteristics. Tap adjust feature eliminates the need for expensive mechanical components with no sacrifice of electrical characteristics. Electrical and mechanical rotation are 320 deg. ± 5 deg. Type CT-200 is a $\frac{1}{2}$ by

Whatever Your Vari-Speed Requirement...



has the answer...

- Variable speed pulleys with exclusive cam and cam follower feature that assures constant speed regardless of load variations. Ratios to 2.6 to 1. Fractional to 5 hp.
- Wide V-belt variable speed pulleys with cam and cam follower feature as above. Speed ratios to 3 to 1. Fractional to 5 hp.
- Hi-Ratio variable speed pulleys for economy and exceptional efficiency at speed ratios as high as 7 to 1.
- Dual ratio compound drives to provide a compact unit for obtaining speed ranges not possible with a single pulley.
- Motor bases in a full range of types and sizes: adjustable, tilting and movable countershaft. Also motor frames.
- Wide V-belt sheaves and wide variable speed belts, sizes from .087 to 14

You'll find the answer to any vari-speed application in Hi-Lo's complete line. Ask for recommendations on your requirement. Request Bulletin HL-60.

Manufactured By
**HI-LO
MANUFACTURING
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**LOVEJOY FLEXIBLE
COUPLING COMPANY**
4968H West Lake St.
Chicago 44, Ill.

Circle 513 on Page 19



One Lamb FHP motor...up to 100,000 carbon copies mass-produced to exacting specifications

From a prototype . . . hundreds OR thousands of motors with absolute uniformity. Each and every motor produced has the same, discriminating, "built-in" perfection that you can expect with Lamb® manufacturing. This precise mechanical and dimensional uniformity of motor as an integral component for your powered product is extremely important . . . and Lamb makes sure you get it!

If you have a special motor problem . . . here's what you can expect from Lamb! *Into the design* of a Lamb motor goes years of experience in powering components for aircraft, domestic and industrial products. *Out of the design* comes a personalized motor that's dependable, smooth and efficient.

Cost-wise you're way ahead, because Lamb Motors are mass-produced at the most favorable cost.

Write today for descriptive folder. Or ask to have a District Engineer call and set up a personalized "Motor Conference".

THE LAMB ELECTRIC COMPANY • Kent, Ohio
A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric—Division of Sangamo Company, Ltd.
Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION
FRACTIONAL HORSEPOWER **MOTORS**

Divisions of American Machine and Metals, Inc., New York 7, New York TROY LAUNDRY MACHINERY
RIEHL TESTING MACHINES • DEBOHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC CO. • HUNTER SPRING CO. • GLASER-STEERS CORP.

Circle 514 on Page 19



An unusual square section neoprene belt, lathe cut by WILBOW, drives the footage counter of this new Webcor Tape Recorder.

WILBOW precision rubber parts improve performance

Design efficiency is the keynote of the new Webcor Tape Recorder line for 1961. An example is the square section neoprene belt that drives the tape footage counter. Developed by Webcor and WILBOW engineers as a cooperative project, this new belt provides improved characteristics of strength, recovery and uniformity of tension . . . at lower cost!

WILBOW specializes in the production of precision mechanical rubber parts to meet new or unusual design needs. A full range of fabrication techniques—lathe cutting, extruding, punching or molding—together with a complete line of synthetic, natural or silicone polymers is at your service. Why not call a WILBOW engineer today?



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COMPLETE
WILBOW CATALOG

Wilbow

The WILLIAMS-BOWMAN RUBBER CO.

1951 South 54th Avenue • Cicero 50, Illinois • (Chicago Suburb)

Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

Circle 515 on Page 19

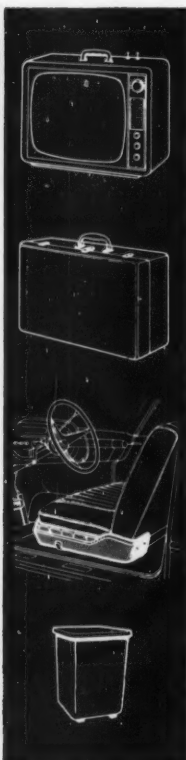
Something New! IN CAVITY AND CORE MOLD DECORATIONS



SKILLED ARTISANS and MASTER DECORATORS of ROLLS, DIES and MOLDS

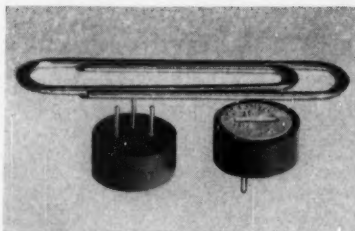
Skilled artisans in decorating cavities and cores for plastic injection molding. Skilled artisans in decorating dies for blow molding. Skilled artisans and master decorators in using anything that can be drawn in pen and ink, and by a unique decorating process, convert the design with exactness to rolls, dies and molds. . . . Write for information and samples.

**ROLL-DIE & MOLD
Decorators, Inc.**
P. O. BOX 2493
YOUNGSTOWN, OHIO



Circle 516 on Page 19

NEW PARTS AND MATERIALS



1/2-in. square trimmer for stability under extreme conditions. It is available with printed-circuit terminals or Teflon-coated wire leads. CT-200 has exceptionally high moisture characteristics. Standard resistance range of both the units is 10 to 50,000 ohms, standard resistance tolerance is ± 5 per cent, and power rating is 1 w at 60 C. Operating temperature range is -55 to 150 or 225 C. **International Resistance Co.**, 401 N. Broad St., Philadelphia 8, Pa.

Circle 663 on Page 19

Styrene-Based Plastics

are available in a
variety of colors

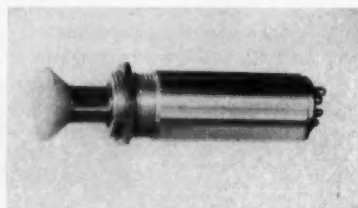
Lustran styrene-based plastics for molding and extrusion have performance and physical properties ranging from those of paper to those of some metals. The two types combine excellent rigidity, toughness, and high tensile strength, in addition to superior abrasion resistance, thermal stability, appearance, and ease of processing. Applications include appliances, automobiles, luggage, telephone hand sets, shoe heels, television, and toys and packaging. **Plastics Div., Monsanto Chemical Co.**, Springfield, Mass.

Circle 664 on Page 19

Switch Light

has choice of
six lens colors

J8000 push-push switch light is a double-pole, double-throw switch



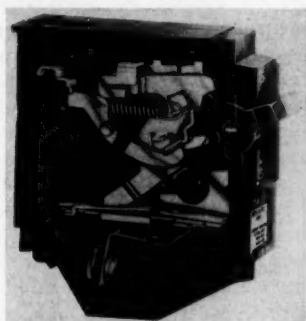
MACHINE DESIGN

with independent light circuit rated at 28 v dc or 115 v ac. Features include nickel-plated brass plunger and anodized-aluminum case, six lens colors to choose from, and overall dimension of 2-33/64 in. Control Switch Div., Controls Co. of America, Folcroft, Pa.

Circle 665 on Page 19

Circuit-Breaker Mechanism

is duplex unit in single breaker space



Circuit-breaker mechanism is designed for back-to-back assembly in a circuit-breaker case of standard size. Resulting duplex breaker incorporates all the electromechanical features of single-circuit units, including reliability, and fits in the same space that a single-breaker load center occupies. Breaker mechanism is mechanically attached to a rigid steel back plate, assuring accuracy of contact-arm movement and freedom from case warpage. Mechanical support is independent from the urea-plastic breaker case, so that mechanism can be dropped into the case during assembly operations rather than assembled in the case. Duplex breakers are available in the following ratings: 15 amp-15 amp; 15 amp-20 amp; and 20 amp-20 amp at 120/240 v ac. Load center panel boxes are available in 2 through 42 circuit sizes in various types. Bryant Electric Co., Bridgeport 2, Conn.

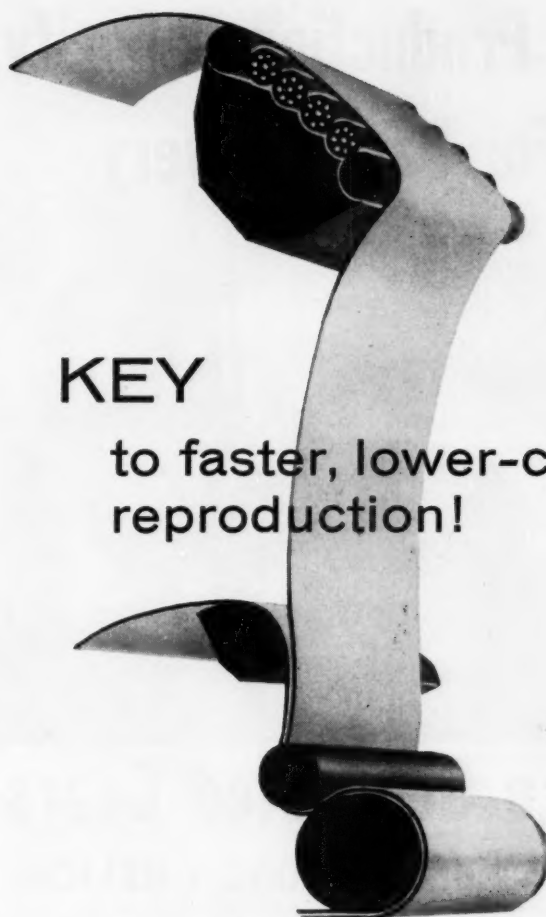
Circle 666 on Page 19

Miniature DC Motor

for use in temperatures to 200 F

Type HYQM 1-in. diam dc motor is available for use in battery-powered equipment of commercial

January 19, 1961



KEY

to faster, lower-cost reproduction!

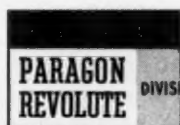
Heart of the Paragon-Revolute Star is its unique separation and development system — key reason why the Star will provide you more print production, per machine, per labor dollar.

The Star's air suction separation device is virtually infallible. At high speed, or any speed, the tracing and print are picked off the exposure cylinder by a unique air-knife and automatically separated by air suction.

In the Star's developing section, exclusive, patented features assure full

development in one pass, at any speed. A preheater tube prepares incoming ammonia for "demand" vaporization. Perforated stainless steel rollers allow virtually 100% exposure of sensitized sheets to the vapor. Prints travel a shorter route, come through clearer, faster, and there's 1/4 to 1/2 less ammonia consumption.

You owe it to yourself and your company to investigate the Revolute Star before buying any whiteprinter. The coupon brings you full details by return mail.



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Paragon-Revolute

Advertising Department, Dept. PL-W
1800 Central Rd., Mt. Prospect, Illinois

Please send me information on your Star whiteprinters. Please arrange for a representative to contact me about a demonstration.

Name _____ Title _____

Company _____

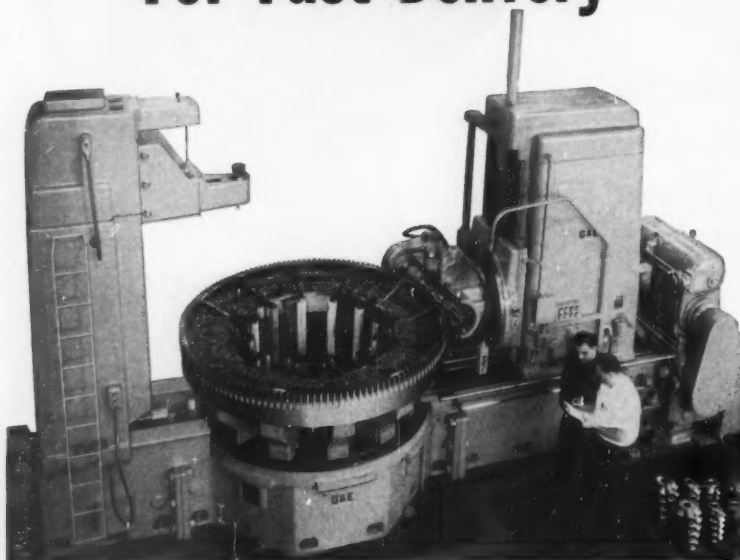
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City _____ Co. _____ State _____

Circle 517 on Page 19

195

New Production Capacity For Fast Delivery



Large Generated Gears SPUR • HERRINGBONE • HELICAL for a wide range of industrial applications

Gears which must operate smoothly and without vibration at higher speeds and under greater loads must correspondingly be more accurate in tooth profile and spacing.

H & S Generated Gears answer these demands.

Offering the same high-quality standards which characterize the complete H & S Gear line, production capacities for large generated Spur, Helical and Hobbed-Herringbone Gears are now available in the following dimensions:

- Up to 80" outside diameter at 1 DP
- Up to 90" outside diameter at 1 1/4 DP
- Up to 100" outside diameter at 1 1/2 DP
- Up to 125" outside diameter at 2 DP

Face widths up to 42", depending on helix angle

Send your specifications, or let our technical staff make recommendations. H & S specializes in fast production of quality industrial Gearing and Speed Reducers to meet your custom requirements.

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5112 Hamilton Avenue • Cleveland 14, Ohio

NEW PARTS AND MATERIALS



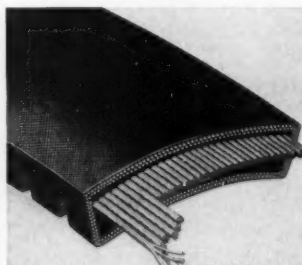
quality, such as dictating machines, tape recorders, phonographs, and marine navigational units. Features of the unit include: High efficiency, low current drain for long battery life; square brushes with pigtail connections for long life; availability with or without a governor; standard self-aligning sleeve or ball bearings. Motor is available for any voltage between 4.5 and 30 v dc. Governed speed can be set from 1500 to 5000 rpm. Torque is 0 to 0.20 oz-in. Rotation is clockwise or counterclockwise. Motor is suitable for operation in ambient temperatures to 200 F. Motors & Components Div., Barber-Colman Co., Rockford, Ill.

Circle 667 on Page 19

Adjustable-Speed Belts

in 7/8 to 3-in. widths
for industrial uses

New adjustable-speed belts withstand the intense squeezing action of pulley sheave walls and provide smooth transmission at full power capacity. Top widths of standard sizes range from 7/8 to 3 in. and nominal over-all lengths range from 26.4 to 170 in. Available for all industrial applications, belts are fabricated from fiber-reinforced synthetic rubber which is impervious to oil and heat and remains live under static conditions. Length stability is assured by the high stretch-resistant properties of the



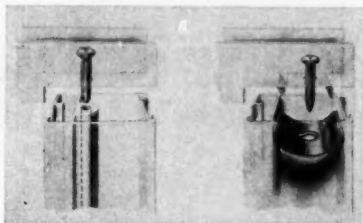
reinforcing cords. Uniform notching on the under side provides ample flexibility without excessive strain or distortion on small pulley applications. Lovejoy Flexible Coupling Co., 4882 W. Lake St., Chicago 44, Ill.

Circle 668 on Page 19

Spring Fastener

for extruded
channel sections

Aluminum-Type spring fastener designated Channeloc, consists of a rectangular, dish-shaped unit with two square edges. Screw hole is formed with a cone impression, and fastener is hardened for optimum resiliency. When another channel section is fitted at right angles to the first one, a self-tapping screw is tightened



into the fastener. Proper tightening compresses the dish-shaped fastener, causing square ends to bite into the aluminum channel sides, securing both frames together. George K. Garrett Co. Inc., Torresdale Ave. at Tolbut Street, Philadelphia 36, Pa.

Circle 669 on Page 19

Worm-Gear Speed Reducers

incorporate fan cooling

Worm-gear speed reducers offer horsepower capacities up to 80 per cent higher than those of conventional reducers of the same type; space savings of 50 per cent and more are possible between two reducers of the same rating. Line is available in nine sizes with 3 to 12-in. center distances. Ratios extend from 4-1/7:1 to 95:1, ratings from fractional to 175 hp. Advantages of the new reducers are due mainly to use of fan cooling. Plastic or aluminum is employed in the design of the light radial fan which is equally effective in either direction of rotation. Fan is mounted on

(Please turn to Page 200)

Important facts to know about laminated plastics



A few Taylor composite laminates (left to right): copper-clad section; sandwiched copper component; Taylorite vulcanized fibre-clad part; laminated tube, copper inserts.

Composite Laminates Open Up New Design Opportunities

While the great variety of commercially available laminated plastics satisfy most electrical and mechanical requirements, there are applications that can benefit from the combination of properties provided by composite laminates. Recent advances in bonding techniques have made it possible to bond virtually any compatible material with a laminate. These can be supplied as clad or as sandwiched materials. And they can be molded into many shapes to fit design requirements. Taylor is presently supplying to order the following composite laminates:

- **Copper and laminated plastics.** Clad for printed circuits and formed shapes. Sandwiched for special applications.
- **Taylorite® vulcanized fibre-clad laminates.** These combine the high strength of laminated plastics with the superior hot-arc-resistance of vulcanized fibre. They are being used in both high and low-voltage switchgear applications. Also in applications where the high impact strength of vulcanized fibre may be advantageous.
- **Rubber-clad laminates.** Almost any type of natural or synthetic rubber may be used as the cladding material. These laminates are widely used for condenser tops in wet condensers to protect the laminate against highly alkaline electrolytes. They also have application in any part where sealing or chemical resistance is needed.
- **Asbestos-clad laminates.** For applications where high heat- and arc-resistance are required.
- **Laminate-clad lead.** Lead sheets sandwiched between Grade XX pa-

per-base laminates have been used for X-ray shields. The laminate provides strength and contributes to the high shielding properties of the lead.

- **Aluminum-clad laminates.** These have been used extensively for engraving stock. They also offer possibilities as printed-circuit material and as plate holders for X-ray machines.
- **Beryllium copper-clad laminates.** Beryllium copper is nonmagnetic and a good conductor—properties that give these laminates possibilities in many applications.
- **Stainless steel-clad laminates.** Applications where nonmagnetic properties are required. Also in certain corrosive environments where the resistance of stainless steel to attack is an asset.
- **Magnesium-clad laminates.** These laminates have been produced in 108-in.-long sheets for use as screens for X-ray operators. Weight was a factor.

Our design and production engineers are constantly developing new materials, new applications, and new procedures for fabricating laminated plastics. Our experience is yours for the asking. And if you have a problem requiring assistance or more information on composite laminates, write us. Also ask for your copy of Taylor's new guide to simplified selection of laminated plastics. Taylor Fibre Co., Norristown 47, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE



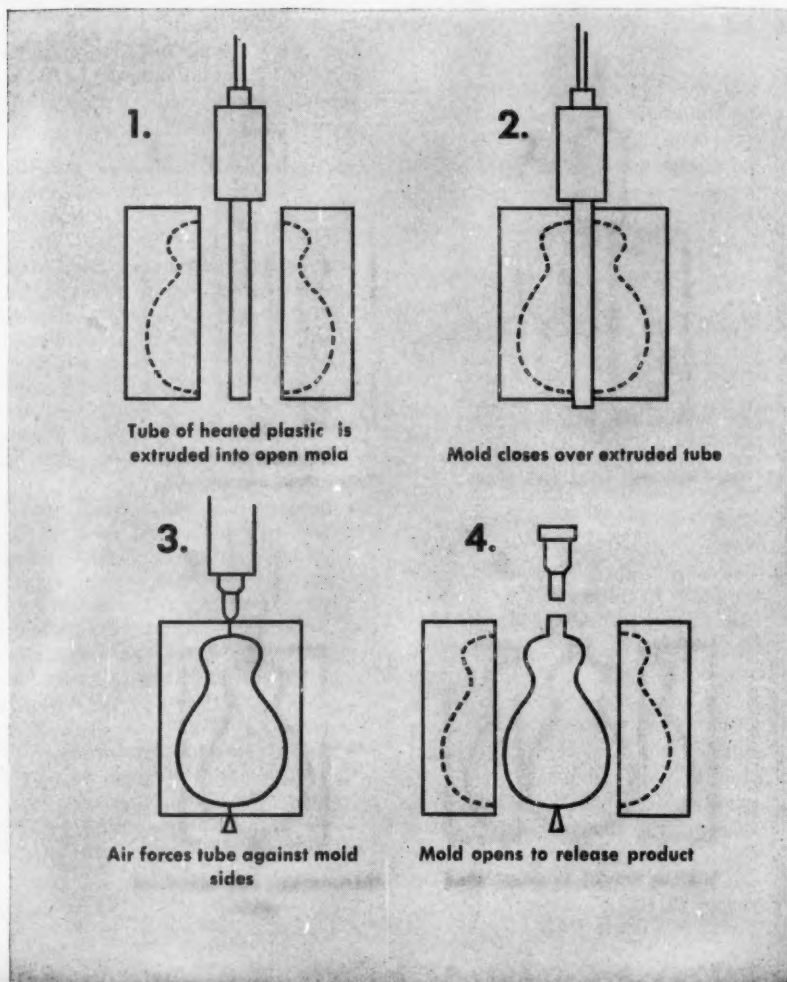
The auto industry warms up to blow-molded polyethylene

These complex shapes you see are sections of heater ducts for Chrysler Corporation cars, blow molded of BAKELITE Brand high-density polyethylene. Each part is made in *one piece*. These components must fit together easily and precisely, yet this method produces them economically. They are tough and light-weight, characteristic of the material from which they are made. They show the designer new sizes and shapes he can now work with in polyethylene.

BLOW MOLDING PUTS BIG DESIGNS

Blow molding is economical

Economy is a major advantage of the blow molding process. All you need is the mold cavity; the core is air pressure itself. Essentially, the operation begins when an extruded tube of heated plastic is placed within the two halves of a mold. An air blast into the tube forces it out against the mold, which is then opened, allowing the blown piece to be removed. Since air pressures seldom exceed 80 psi, molds can be made from low-cost materials and tooling up is fast. The plastic is formed at relatively low temperatures. That means faster cooling. Refinements of the basic process allow cost-cutting automation. Even injection molding equipment can be adapted to the process for special requirements.



**50% cost reduction was just
one of the benefits...**

This traffic blinker housing is two feet long. It, too, is made in *one piece* by blow molding high-density polyethylene. Any other technique would have required a two-piece assembly. Previously constructed from sheet metal stampings, it required not only assembly but a separate coating operation as well. Blow molding saves 50% of former production costs! Molds can be made quickly and inexpensively. The color is molded in. BAKELITE Brand high-density polyethylene also gives the product lightness, rigidity, and durability.



IN PLASTICS

Since participating in the development of the squeeze bottle, Union Carbide has been refining the techniques and materials for blow molding. Facilities for studying production-line blow molding at the Bound Brook, N. J., laboratories are unsurpassed. A battery of blow molding machines there reproduces every set of conditions encountered in the process. This equipment, in addition to providing basic knowledge about blow molding, helps in developing new BAKELITE Brand polyethylenes—high-, medium-, and low-density, and copolymers. You can select from the greatest variety available at one source, confident of getting the formulation best suited to your needs.

For information on application of these materials and processes to your products, write Dept. IM-84, Union Carbide Plastics Company, Division of Union Carbide Corp., 270 Park Ave., New York 17, N. Y. In Canada, Union Carbide Canada Limited, Toronto 12.



BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

Circle 520 on Page 19

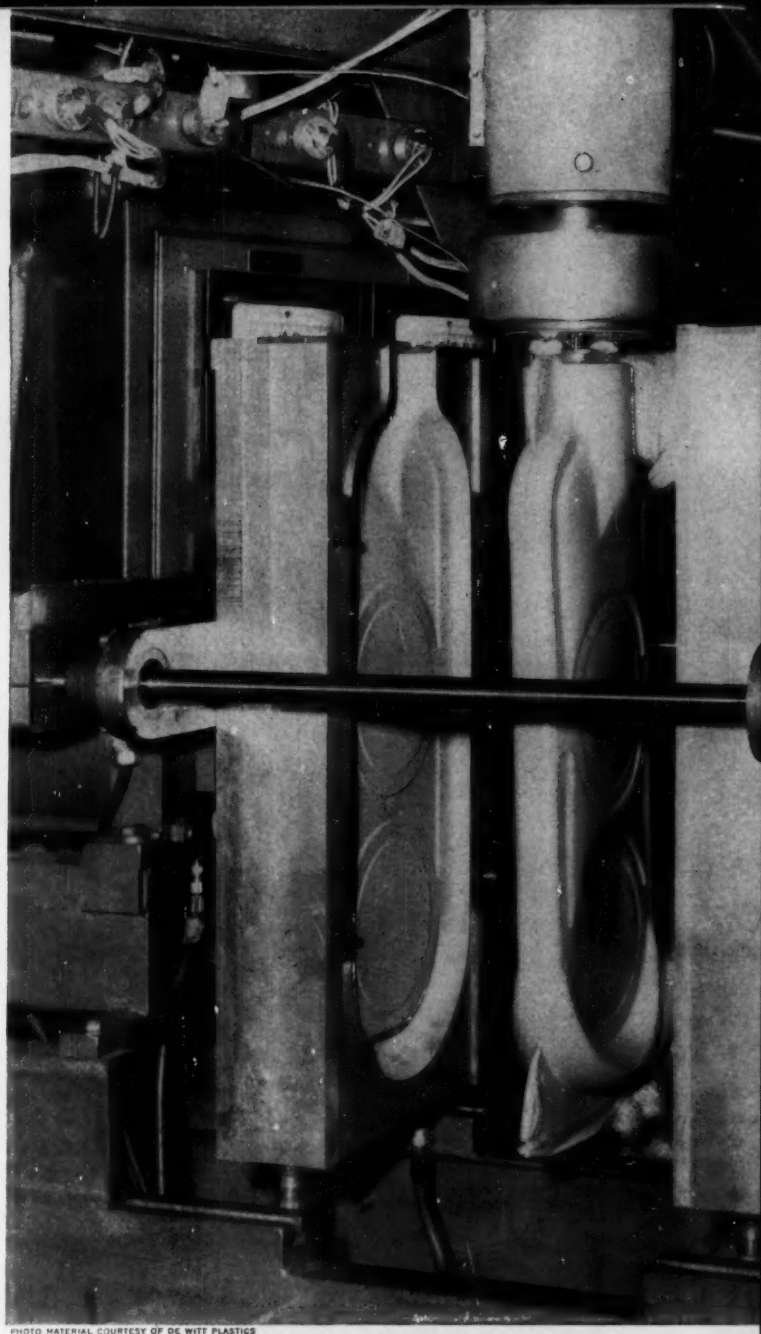
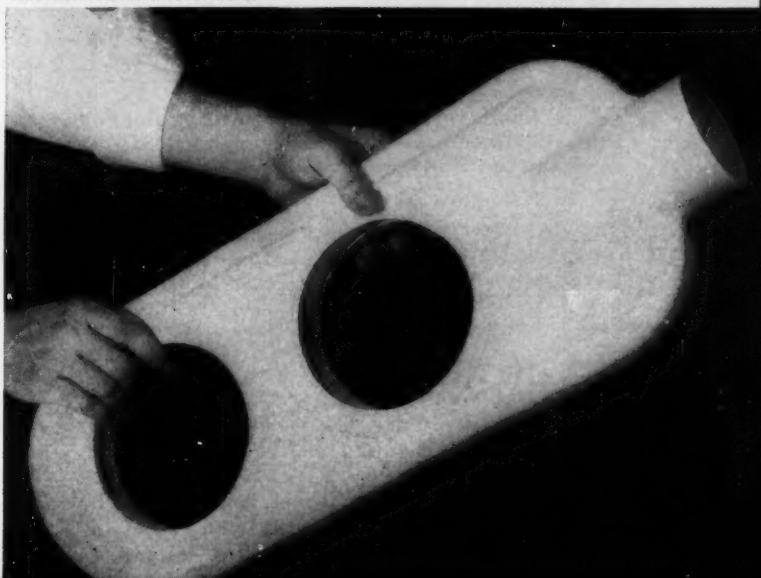


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THE FREEDOM DIMENSION



... is shape flexibility

The investment casting process allows a new *freedom of design* ... in shape ... in materials. You can now design for function—the way you want the part!

This functionally designed instrument chassis was poured as an investment casting without design compromise. Dozens of expensive and complicated machining operations would otherwise have been required. Check your design with Hitchiner—in many cases you can buy *just what you want*.

Write for
complete
technical
and facilities
information.

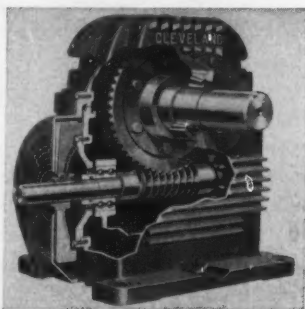


HITCHINER
Milford 1, New Hampshire

Circle 521 on Page 19

NEW PARTS AND MATERIALS

(Continued from Page 197)



the input side of the worm shaft to scour the finned outer wall of the reducer. Mounting in this position eliminates the extra expense and friction loss involved in the addition of another oil seal. Cleveland Worm & Gear Div., Eaton Mfg. Co., 3300 E. 80th St., Cleveland 4, Ohio.

Circle 670 on Page 19

Carbon-Graphite Material

for use at temperatures
to 1200 F

New grade of Graphitar carbon graphite has greater resistance to oxidation and high temperatures than grades previously available. Grade 2573 is suitable for parts that operate in oxidizing atmospheres, such as air, at temperatures to 1200 F. Lower coefficient of friction, improved wear resistance, and greater stability are other advantages of the material. Material can be formed into intricate shapes, and ground to tolerances of 0.0005 in. or less. It is widely used for seals, bearings, end plates, valves, liners, bushings, and similar parts. United States Graphite Co., Div., Wickes Corp., Saginaw, Mich.

Circle 671 on Page 19

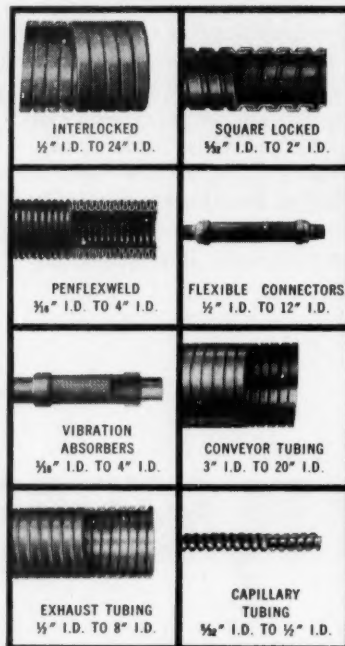
Carbon Potentiometer

for temperatures to 150 C

Resiston carbon Trimpot potentiometer provides high reliability at operating temperatures to 150 C. Model 3051 features a high-tem-



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When your new product requires flexibility in conveying air, water, steam, gases, volatiles, granular, abrasive or light solid materials, specify Penflex. It's the flexible metallic tubing with complete engineering service from design board to the job installation.

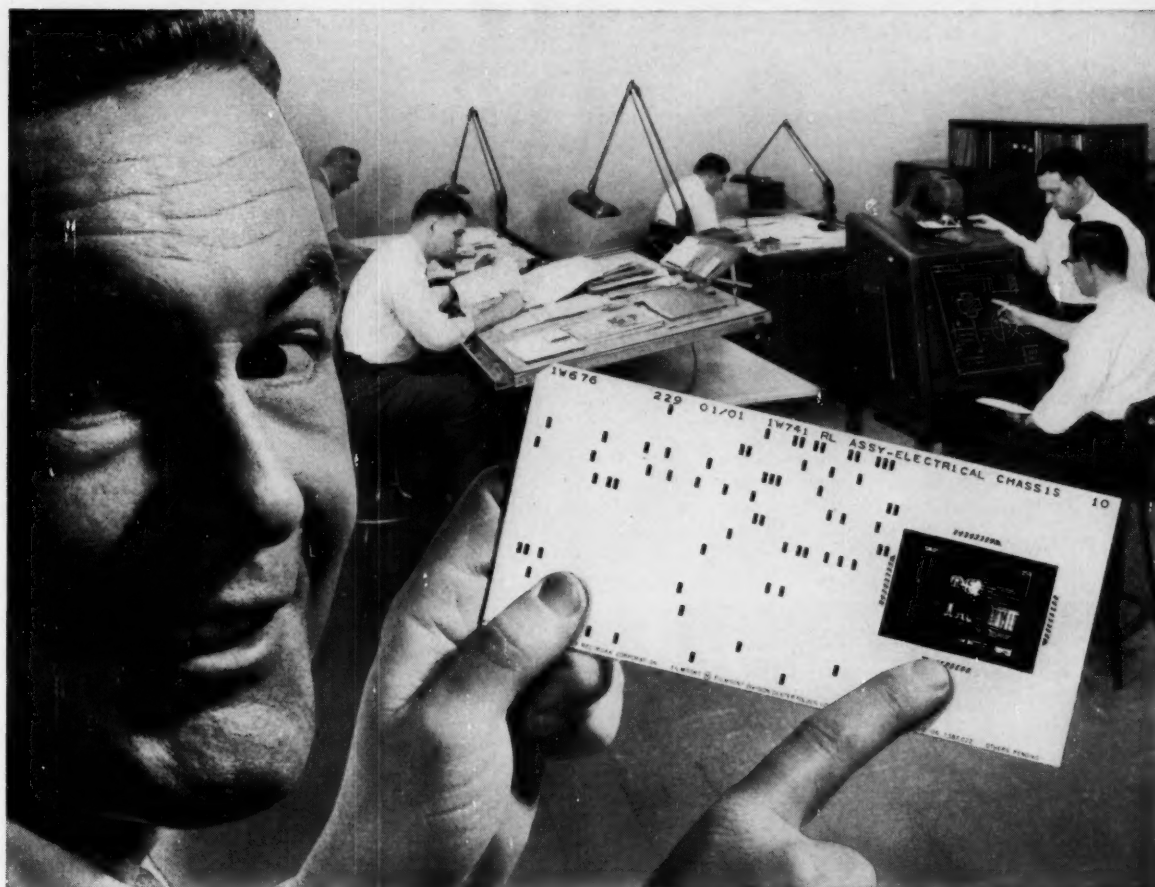
Penflex offers a complete line of all types and sizes of flexible metallic tubing. Corrugated and interlocked, steel, stainless steel, or bronze in sizes from 1/8" I.D. to 24" I.D. ... rugged, safe to withstand pressures and high temperatures. Write for data application book on flexible tubing to

Pennsylvania Flexible
Metallic Tubing Co.,
Paoli, Pa.



TIGHT AS A PIPE ... BUT FLEXIBLE

Circle 522 on Page 19



Why it's all-important to get good microfilm pictures!

Your success with an automated drawing file depends mainly on the quality of your microfilm reproductions.

They must be completely legible when checked in film readers . . . they must also produce accurate, easy-to-read paper prints and duplicate microfilms.

Here's where Recordak techniques and quality controls, developed over years of research, pay rich dividends for drafting rooms large and small. They provide remarkably sharp and uniform pictures on low-cost 35mm microfilm which *more than meet DOD requirements* (120 lines per mm resolution at 30 to 1 reduction ratio).

Mounting these superb Recordak microfilm frames in aperture cards gives you an active drawing file

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which can be kept at the finger tips . . . always available for easy viewing in a Recordak film reader.

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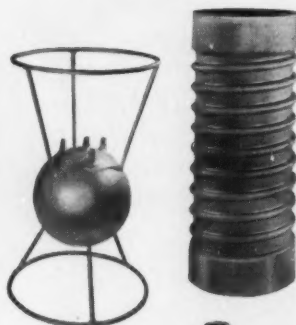
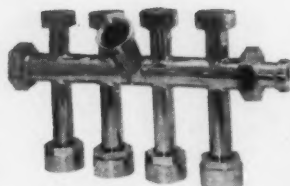
craftsmanship
... dependability
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A-P-C's complete plant integration means better stainless steel components for you. Everything including drawing, stamping, heat treating, pickling, welding, machining, polishing is done under one roof. There's no lost time... no pass-on of responsibilities to sub-contractors. A-P-C facilities are manned by skilled personnel, long recognized as stainless steel craftsmen, the world over. You can be sure of absolute dependability when you buy A-P-C products and services... no run is too small... no run too large. Write today for free illustrated brochure describing A-P-C products and services.

ALLOY PRODUCTS CORP.

1067 PERKINS AVE., WAUKESHA, WISCONSIN

Circle 524 on Page 19



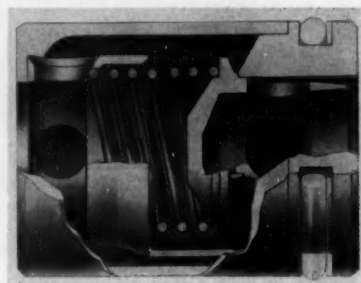
NEW PARTS AND MATERIALS

perature carbon deposited on an inert, moistureproof ceramic base. Unit is completely sealed against humidity. Power rating is 0.25 w at 50 C, range is -65 to +150 C. Size of the unit is 1.25 x 0.32 x 0.19 in., and weight is 0.1 oz. Potentiometer features multiturn screw-driver adjustment with a positive-action idling-post assembly, preventing damage from forced adjustments. Units can be provided for panel mounting, can be mounted individually, or in stacked assemblies using 2-56 screws through body eyelets. Trimpot Div., Bourns Inc., 6135 Magnolia Ave., Riverside, Calif.

Circle 672 on Page 19

Check Valve

operates at pressure
to 5000 psi



C-200 cartridge check valve is placed in a single bored hole as an integral part of any pneumatic or hydraulic system. It eliminates threaded connections and expensive machinery. Valve, available in steel or aluminum in sizes from 1/8 to 3/4 in., operates at pressures to 5000 psi. Cage device positively restrains the O-ring, preventing possible washout. Heavy, rugged body construction provides protection from abuse and unusual pressure surges. Dead-tight sealing and chatter-free operation are additional advantages. Circle Seal Products Co. Inc., 2181 E. Foothill Blvd., Pasadena, Calif.

Circle 673 on Page 19

Elapsed-Time Meter

has six register wheels
indicating to 99,999.9 hr.

Type BH-351 elapsed-time meter is furnished with or without reset knob and is mounted from either



Wolverine

TOGGLE CLAMPS

Cost Less per Thousand Clamping Operations

Note These Important Features:

- HARDENED PINS and BUSHINGS
- HEAVY BODY SECTIONS
- BLACK OXIDE FINISH
- PINS RIVETED FLUSH
- DROP-FORGED ARM



C-110



CQ-1107

Many Types to Satisfy Your Work Holding Needs

8 STANDARD ACTION UNITS
10 QUICK ACTION UNITS
12 PUSH ACTION UNITS & others

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DETROIT 7, MICHIGAN

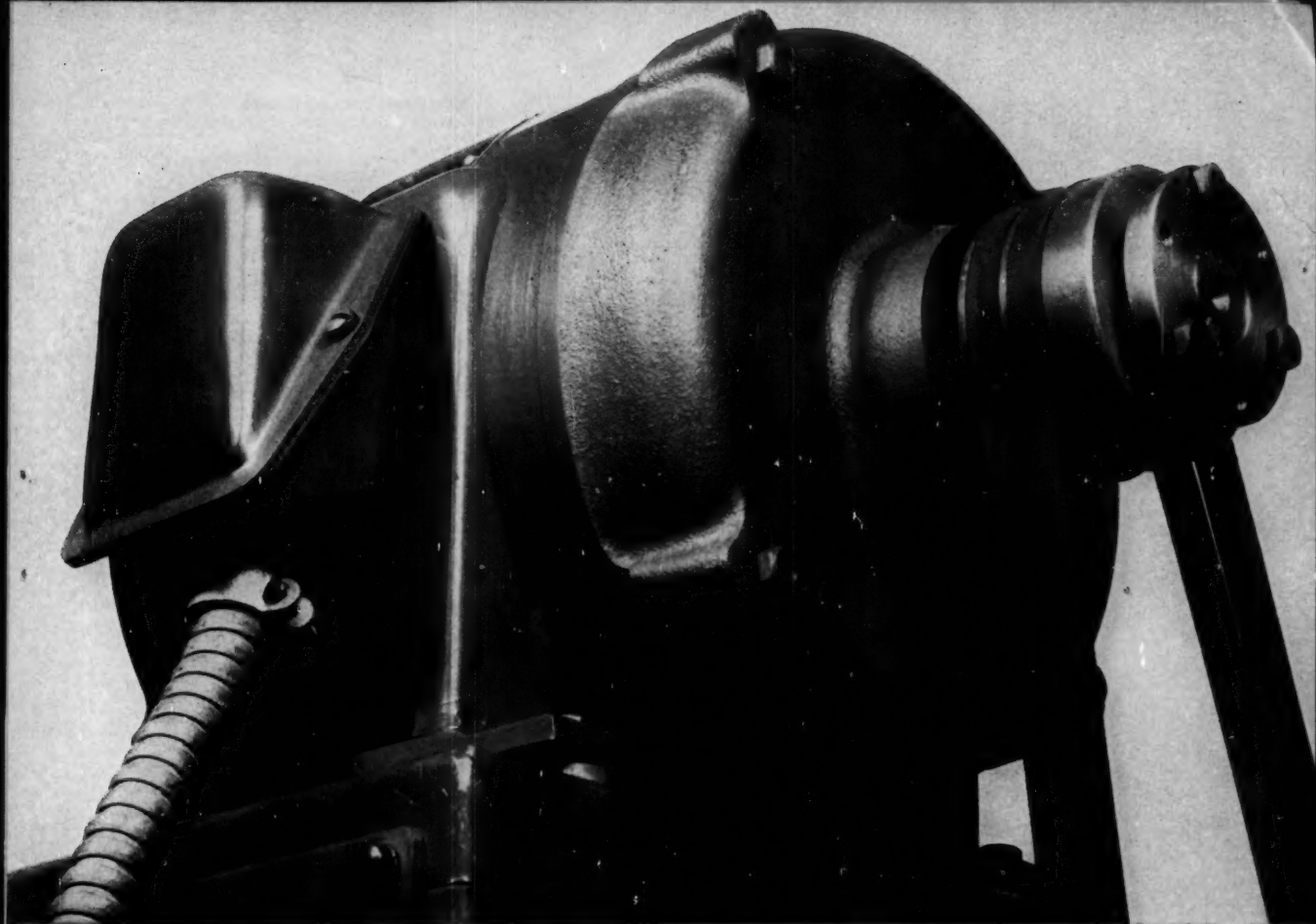


CQ-810



C-150



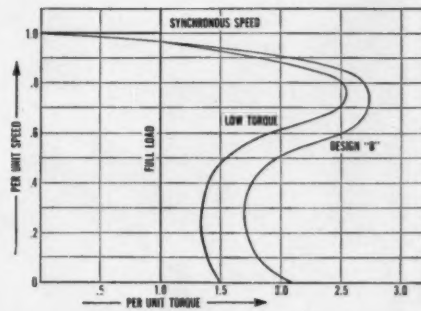


Special Century Motors Control Belt Screech

These Century polyphase motors are designed for *low* starting torque. They are mechanically interchangeable, rating for rating, with Standard Design B motors. But, as shown in the speed-torque curve, they are internally designed for static torque only 50% more than full load torque. There are some applications where this low torque at standstill is an advantage.

Belted drives have always been the cause of some noise—the same disturbing sound made by tires skidding on pavement. Flat belts had a characteristic sound at all times, varying from a “singing” sound to a real “screech.” In recent years, quiet belted drives have been possible with the universally used V-belts. A continuing problem has been to start the driven machine without a few seconds of screech. When the typical motor (Design B or Design C) is energized, it develops so much torque that even properly applied V-belts are apt to screech as they bite into the sheaves. In many locations this noise is objectionable. And the high starting torques impose unnecessary strains on the driven machine.

For driven machinery (such as blowers) having a low starting torque requirement, we have found that the objectionable noise can be eliminated by this special design motor. This proved to be a simple solution to a vexing problem for several of our customers. For help on your motor problems, call your Century Sales Office.



Comparison of typical rating — NEMA DESIGN “B” and SPECIAL LOW TORQUE DESIGN

CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri Offices and Stock Points in Principal Cities

Circle 526 on Page 19

Century
60-1



WAPAK HARDENED WAYS LAST LIFETIME OF YOUR MACHINES

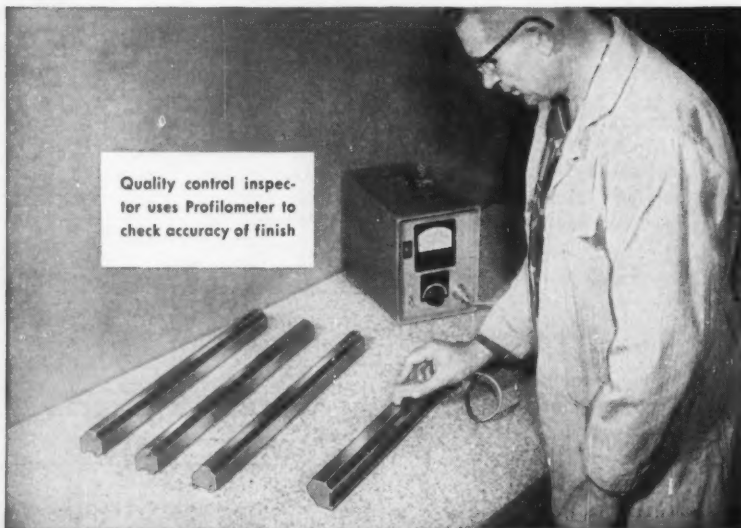
Engineered from solid tool steel, WAPAK Hardened Ways are uniformly hard through and through . . . No galling, scoring or other failure throughout lifetime of your machines . . . even under rugged service. Carburized or laid steel ways also available in some sizes.

ACCURATE FINISH

Utmost care is given to accuracy of finish on all WAPAK Hardened Ways. Micro grinding is followed by individual inspection of each piece with Profilometer.

ENGINEERED TO SPECIFICATIONS

WAPAK Ways are manufactured to your blue print specifications and normal deliveries maintained. Your machines are more reliable with WAPAK Hardened Ways.



Quality control inspector uses Profilometer to check accuracy of finish

THE **WAPAKONETA** MACHINE CO.

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NEW PARTS AND MATERIALS



the front or back of the panel. Since the meter indicates the total time that a particular circuit is energized, it is suited for such applications as tube replacement programs and maintenance scheduling of electrical equipment, including diesel generators, motors, welders, and radio and television transmitters. Six register wheels are provided, giving indication up to 99,999.9 hr. All digits are white on black background except the tenths digit, which is black on white. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 674 on Page 19

Vane-Axial Blowers

have wide output range

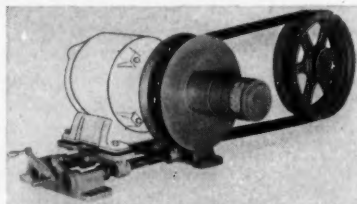
SP-162 vane-axial blower units are available for aviation and electronic instruments and equipment. Designed to meet MIL-E-5272A environmental conditions, the compact cooling units deliver from 275 to 550 cfm at static pressures of 7.5 to 1.5 in. of water (standard density). Blowers have either 400-cps ac or dc motors, weigh 7½ lb, are 5.75 in. long and have 7.54 in. diam. Specialty Blower Div., Torrington Mfg. Co., Torrington, Conn.

Circle 675 on Page 19

Adjustable-Speed Drive

uses a single belt

Rated 25 hp at 1750 rpm, No. 1325 Roto Cone variable-pitch pulley



MACHINE DESIGN

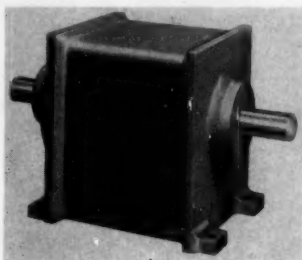
provides an adjustable-speed drive that gives 3:1 speed-change ratio. Used with adjustable motor base, one variable-speed belt, and a companion V-Groove sheave, pulley drive converts any constant-speed motor or other driving power source to an adjustable-speed drive that delivers infinite speed control for any desired speed within the speed range, instantly and accurately while the machine is in operation. Gerbing Mfg. Corp., Elgin, Ill.

Circle 676 on Page 19

Clutch-Brake Drives

six sizes are furnished as foot or flange-mounted units

New line of high-performance clutch-brake drives are for use on all types of industrial machines, special machinery, and automation equipment. Clutch and brake are



mounted in an integral welded-steel housing and operate in a self-contained oil bath. Forced air cooling is provided on the larger sizes. Clutch can be actuated by any three-way pneumatic or hydraulic valve. Brake is spring operated and is released automatically by mechanical interlocking with the clutch. Six different sizes are furnished as either foot or flange-mounted units. Maximum operating speed is 1200 rpm. Sommer Associates, 326 N. Western Ave., Chicago, Ill.


Circle 677 on Page 19

Junction Block

has crimp-on cable connections

ConheX junction block is available for tapping runs of subminiature coaxial cable. Block features crimp-on cable connections which reduce

(Please turn to Page 208)



One word explains the popularity of these switches...

Dependability!

Denison LOXSWITCH Limit Switches operate with the dependability of Old Faithful. Oil- and dust-tight features, superior electrical characteristics and mechanical design result in three to five times longer life than comparable switches.



L100W HEAVY DUTY LIMIT SWITCH

- 45 CIRCUIT ARRANGEMENTS.
- LONGEST CONTACT LIFE due to lowest impact of 2.5 grams and minimum "bounce".
- WATER-, DUST- AND OIL-TIGHT, NEMA 12.
- ONLY FOUR MOVING PARTS. Longer life, easier to maintain.
- 70° SAFETY OVERTRAVEL without use of extra springs or cams.
- OVER 150 LEVER STYLES.

MODEL M PRECISION LIMIT SWITCH

- LONG MECHANICAL LIFE nylon latch mechanism.
- 600 VOLT INDUSTRIAL CONTROL RATING.
- COMPLETELY ISOLATED CIRCUITS.
- 6° TRIP DIFFERENTIAL, 50° overtravel in both directions.
- PRECISION REPEATABILITY $\pm .001"$.
- WATER-, OIL-, DUST-TIGHT - NEMA 12.
- FULLY INTERCHANGEABLE with thousands of existing layouts.



BOTH MODELS AVAILABLE WITH PLUG-IN CONVENIENCE

Write for literature describing our complete line.

Address R. B. DENISON MFG. CO., 386 Broadway, Bedford, Ohio

DENISON LOXSWITCH

Wire with LOXSWITCH and you wire for good!

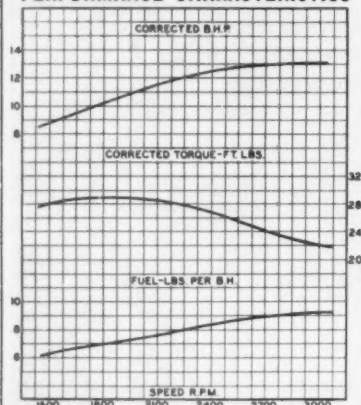
Check these specs against your requirements

Where you need smooth, vibration-less operation . . . light weight . . . space-saving compactness . . . fuel-saving economy . . . and rugged, long-life performance . . . you'll find your answers in Onan's CCK. Note a few of CCK's many applications on these pages. Besides the welder shown, five different makes of portable welders use CCK. Also, leading manufacturers of engine-driven truck refrigeration systems standardize on CCK.

A FEW OF CCK'S FEATURES—

- Stellite-faced exhaust valves
- Solid Stellite exhaust inserts
- Rotating exhaust valves
- Full pressure lubrication
- Jumbo oil bath air cleaner
- Oil pressure indicator
- Magneto ignition
- Governor regulation: 5%
- Extra large bearing surfaces
- Axial-flow pressure cooling
- 3-quart oil sump
- Rugged Alloy C. I. construction
- Short extra-heavy crankshaft

PERFORMANCE CHARACTERISTICS



Performance Tests conducted with all accessories installed, S.A.E. Test Code and data corrected to S.A.E. standard. Engine as shipped will produce at least 85% of corrected bhp. After run-in, power will increase to at least 95% of corrected bhp.

CALL Bob Westrum at Onan for complete information. He's an expert in solving tough power problems for Original Equipment Manufacturers. Minneapolis, Federal 2-1155.



OR write for fact file on CCK including complete line of accessories and other Onan O.E.M. products—including engine-driven electric power plants to 230 KW... separate generators... engine compressors.

Toughest in its Onan CCK

Built for rugged performance



POWERFUL AND QUIET! This Onan-driven golf cart takes two, even three players anywhere on the course. Idles down to a whisper while they're shooting. Smooth control. And remarkably economical with its 1000 rpm governor. Put this versatile 2-cylinder engine in *your* new product planning.

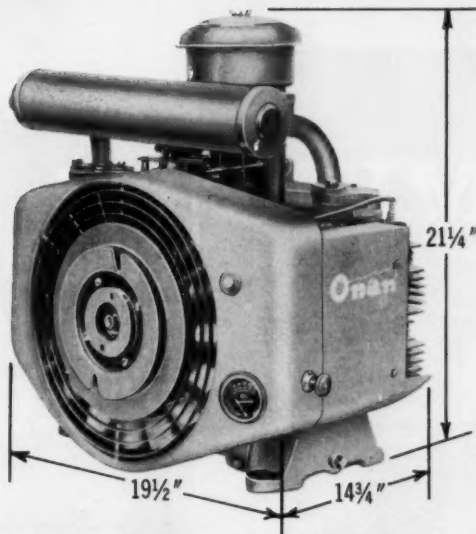


100-MILE-AN-HOUR AIR BLAST! In this high velocity sprayer for pest and sanitation control, Onan CCK engine revs up a storm—with no time out. CCK will deliver up to 13 hp during *sustained* operation at over 3000 rpm. Here's performance and dependability ready to go to work in *your* equipment.

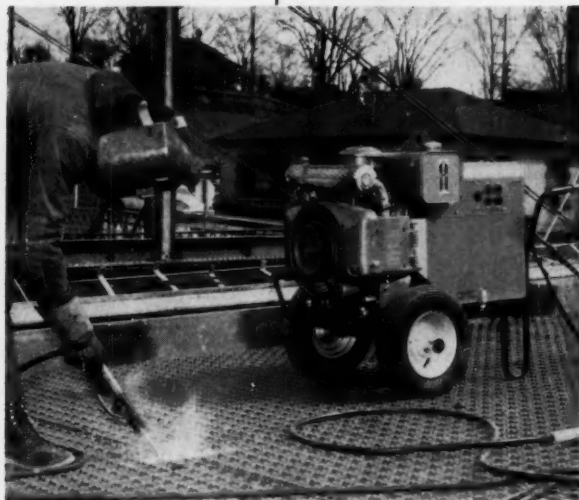
Class! Engine

12.9 hp at 2700 rpm.
Alternate-firing,
4-cycle, 2-cylinder,
opposed, air-cooled,
horizontal design.
Gasoline or gas
operation.

... weighs only 148 lbs.



UP AND AT 'EM WITH 45 FT. REACH! In this hydraulically-operated aerial ladder truck . . . where steady, controlled power drive is vital . . . CCK demonstrates true championship ability. Where can you use this outstanding 2-cylinder engine? Let Onan help.



WEIGHT-SAVING CCK means easy portability in this high-output welder. Goes anywhere. Handles toughest jobs. CCK delivers plenty of reserve power when needed.

IT SWEEPS! VACUUMS! DUMPS! This compact, nimble CCK-driven sweeper solves municipal and other clean-up problems in a hurry. Need maneuverability and compactness in your equipment? Put CCK to work!



**WORLD'S LEADING BUILDER
OF ENGINE-DRIVEN
ELECTRIC POWER PLANTS**

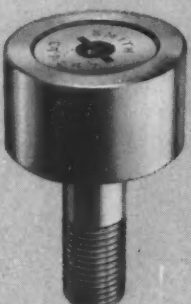
Onan Division,
Studebaker-Packard Corp.
2717 University Ave., S.E.,
Minneapolis 14, Minn.

SMITH

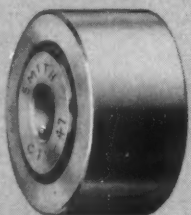
CAM FOLLOWERS AND YOKE ROLLERS



HCS CAM FOLLOWER



CTA CAM FOLLOWER



CTY YOKE ROLLER

Precision Made For Precise Performance

Each component of Smith Cam Followers and Yoke Rollers is carefully engineered, machined and finished to the most exacting standards and dimensions. As a result, each Standard Smith Cam Followers and Yoke Roller is identical to all others of the same series and size.

Such uniformity of product results in equal uniformity of performance

Standard Smith "CTA" (interchangeable) or "HCS" (High Capacity Stud) Cam Followers and "CTY" Yoke Rollers, assure you of outstanding performance with long, trouble-free life.

Special Smith Cam Followers and Yoke Rollers to suit special applications are supplied promptly.

Better distributors throughout the nation stock and sell Smith Cam Followers and Yoke Rollers.

Write for your now, quick reference data sheets.

SMITH BEARING DIVISION

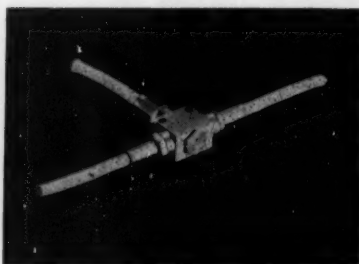
Accurate Bushing Company

441 North Avenue, Garwood, New Jersey

Manufacturers of: Needle Bearings, Cam Followers, Yoke Rollers, Jet Engine After Burner Rollers and Bearing Assemblies, N. A. S. Standard and Special Bearings, High Temperature and Severe Wear Precision Parts.

NEW PARTS AND MATERIALS

(Continued from Page 205)



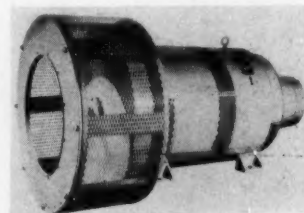
assembly time by approximately 60 per cent as compared to conventional-type assemblies. Block maintains optimum electrical characteristics in both main cable run and tap cable run. Made in T-shape, it has a slotted center coupler to receive center conductor of main-run cable. Main-run cable is cut, dressed, and center conductor is soldered into contact slot. Tap is made by the usual connection through the vertical leg of the T. Sealelectro Corp., 610 Fayette Ave., Mamaroneck, N. Y.

Circle 678 on Page 19

Motor-Generator

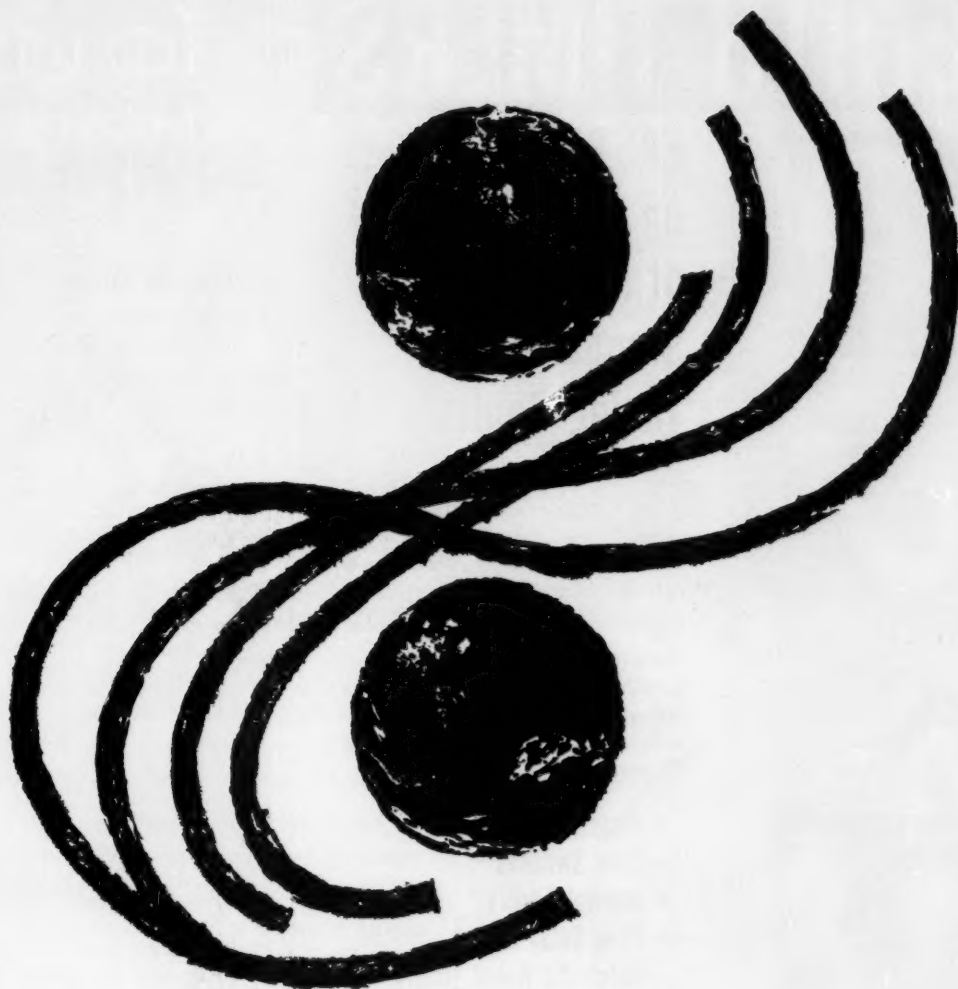
incorporates large flywheel to provide no-break power

In case of failure of normal electric power, the momentum of a large flywheel incorporated in new motor-generator keeps fluctuation at a minimum until standby powerplant is cut into the line. Set features a brushless-type generator with direct-connected separate exciter, is rated at 5 kw, 6.25 kva, 0.8 factor, 120 v ac single phase, 50 cps. Regulator provides 1½ per cent of rated voltage under one-fourth to full-load



conditions. Rectifier assembly is mounted on end of shaft for easy replacement of rectifiers. Motor is 10-hp, 208/416-v ac, 1500-rpm, 50-cycle, three-phase, wound-rotor induction type. Kato Engineering Co., Dept. R, Mankato, Minn.

Circle 679 on Page 19



Said Johann Kepler: *"The planets move in elliptical orbits about the sun, and the square of their periods of revolution are proportional to the cube of their mean distances from the sun."*

With interplanetary voyages fast becoming a reality, complete information regarding the velocity requirements for travel between planets is of vital importance. With these data available, it is possible to analyze propulsion requirements, plan ultimate system configurations, and conduct feasibility studies for any particular mission.

Lockheed Missiles and Space Division scientists have actually evolved a rapid-calculation method, utilizing a high-speed computer. This has produced literally thousands of orbits, velocity requirements, and elapsed time, for design studies of trips to and from both Mars and Venus—every tenth day from now until January, 1970.

More simple to analyze are many factors which make Lockheed Missiles and Space Division a wonderful place to live and work. Located in Sunnyvale and Palo Alto, California, on the beautiful San Francisco Peninsula, Lockheed is Systems Manager for such programs as the DISCOVERER, MIDAS and SAMOS satellites and the POLARIS FBM. These, together with research and development projects in all disciplines, make possible a wide diversity of positions for creative engineers and scientists in their chosen fields.

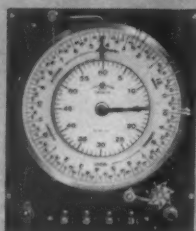
Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-14B, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM; the Air Force AGENA Satellite in the DISCOVERER, MIDAS and SAMOS Programs

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

ZENITH TIMERS



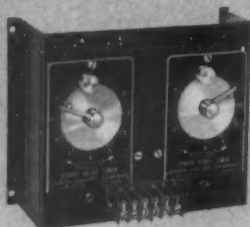
Program Clocks



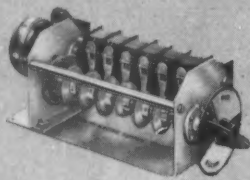
Interval Timers



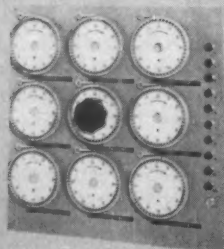
Time Delay Timers



Automatic Reset Timers



Multi-Circuit Cycle Timers



Master Programmers

FAST DELIVERY... on a Wide Range of Special and Standard Timing Controls

Now, choose the right timer for any control requirement from Zenith's versatile line. Save time and avoid delay. Get prompt engineering and delivery on specials . . . immediate delivery on standard controls.

DEPENDABLE—Take advantage of Zenith's experience in engineering and manufacturing quality controls and timing devices for over 35 years.

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- Time Switches
- Interval Timers
- Time Delay Timers
- Automatic Reset Timers
- Multi-Circuit Cycle Timers
- Percentage Timers
- Impulse Timers

Our catalog 18-B also includes

- Automatic transfer switches engineered to assure continuity of power
- Magnetic contactors ruggedly designed for reliable power switching

Write for your copy of Catalog 18-B today. See classified telephone directory for your Factory Representative.



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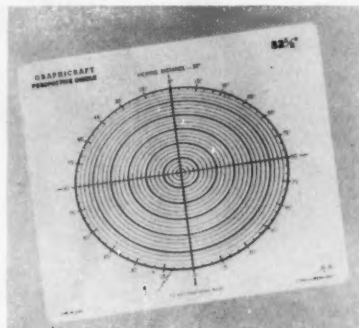
ENGINEERING DEPARTMENT

EQUIPMENT

Perspective Circles

are accurate at
30-in. viewing distance

Set of 27 underlay guides show circles from 1/4 to 6-in. diam at viewing angles from 5 to 70 deg. Steps of 2 1/2 deg give a gradual visual transition of the circle as it moves from one area to another in a perspective drawing. Guides are pre-



cisely accurate at a viewing distance of 30 in. and are compatible with any perspective grid or drawing of similar viewing distance. The 5-deg calibrations enable the guides to be used also as perspective protractors. Guides are heavy, moistureproof bristol for excellent durability. Graphicraft, P. O. Box 509, Westport, Conn.

Circle 680 on Page 19

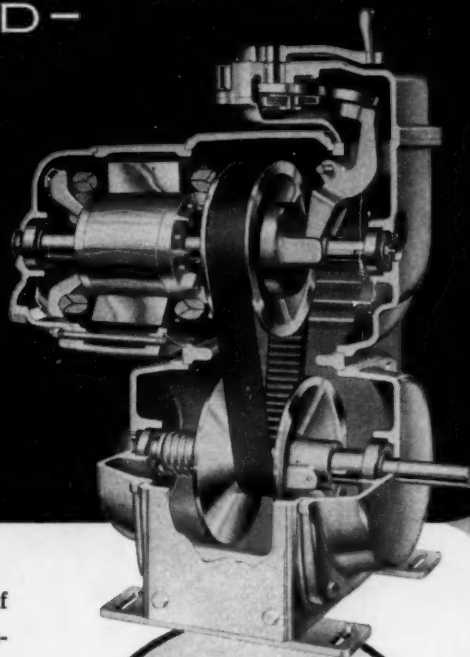
Stack-Switch Kits

for making prototype
working switch samples

Stack-switch experimental kits can be used in design, experimental work, and on prototype projects. Kits permit making of working samples of switches during design stages; revisions and changes in the switching to meet particular requirements can then be made. Three kits are available. No. K-101, recommended for use in deciding which spring-switch design would be most suitable, consists of 74 springs in nine

NO CREEPAGE FROM SET SPEED—

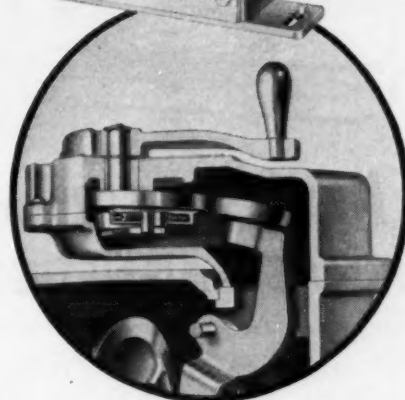
ANOTHER
DESIGN
ADVANTAGE
of the
New Sterling
Fractional Horsepower
Variable Speed Drive!



Reliable speed control *without creepage* is but one of the major design advantages of Sterling's new Fractional Horsepower Variable Speed Drive. Whether you select the fine adjustment handwheel that goes through the 10:1 speed range in six turns or the fast action lever control that requires less than one turn for the entire range, reliability is assured.

Sterling's creepage eliminator utilizes a cam and bearing with a positive roller-wedge lock. This exclusive design also has direct linear response: for every change in the control lever (or handwheel), there is an equal change in output speed.

The control mechanism can be mounted in three positions, on either side or on top. In addition, electric, pneumatic and mechanical remote controls are available to meet your needs.



Available in ratings of $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ hp, the compact, lightweight Sterling Fractional Horsepower Variable Speed Drive provides infinitely variable speeds from 4660 to 1.2 rpm.

For dimensions, prices, and other specific details concerning the use of this new Sterling drive in your fractional applications, contact your local Sterling office, or write direct for a free copy of Bulletin 201.

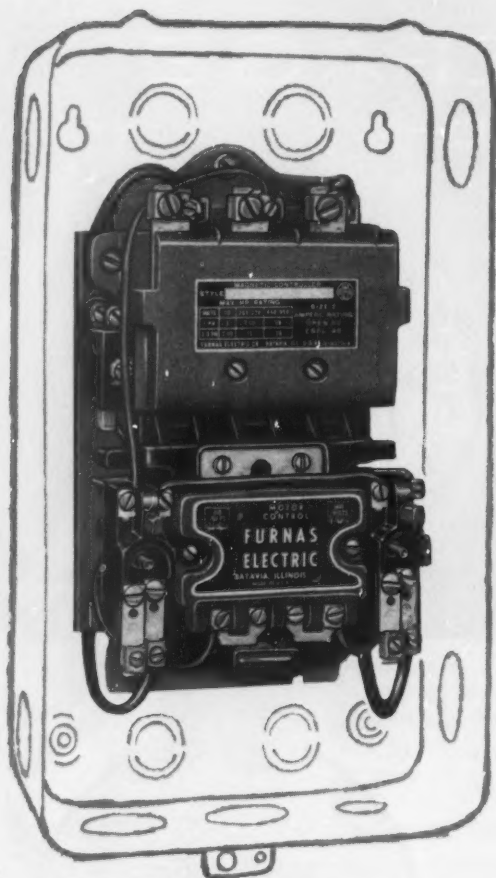


STERLING ELECTRIC MOTORS, INC.

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A subsidiary of HATHAWAY INSTRUMENTS, INC.

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NEW SIZES 2 and 2½ FURNAS MAGNETIC STARTERS

Take advantage of the new design of Furnas Size 2 and Exclusive Size 2½ Starters. Rated through 30 hp, 440 volts, the Size 2½ fills many applications normally requiring a much larger Size 3 Starter. Available for two, three or four pole applications, these units feature low wattage magnet, dual voltage encapsulated coils, silver-cadmium oxide contacts, and identical mounting area for both sizes. All components are front removable. You get better performance and longer life, plus unmatched economy.

Write today for Bulletin 14-B2—1045 McKee St., Batavia, Illinois

A93



FURNAS

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SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

ENGINEERING DEPT. EQUIPMENT

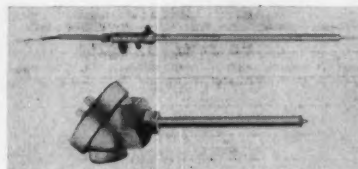
different thicknesses; over 115 phenolic spacers and insulators in seven variations of design; hard rubber insulating tubing; two different sets of stack assembly pins; two roller assemblies; assorted contacts. All contact springs and associated parts are furnished in ¼ and ⅜ in. mounting centers. Kit K-102 contains contact springs and associated parts with ¼-in. mounting centers, and No. K-103 includes springs and parts with ⅜-in. mounting centers. Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.

Circle 681 on Page 19

Temperature Sensors

for use to 4000 F

Thermocouple-type temperature sensors are noncooled and cooled types to measure liquid, solid, and gaseous temperatures. Some of the units are usable in oxidizing atmosphere to 4000 F and intermittently higher. Tantalum and molybdenum with



oxidation-resistant coatings are used in manufacture of the sensors. Insulation is magnesia and beryllia, and thermocouple wires are iridium, tungsten, rhenium, and alloys of these elements. Typical applications include measuring temperatures of molten glass, fuel pins of a nuclear reactor, missile nose cones, combustion processes, and flue gas. Aero Research Instrument Co. Inc., 315 N. Aberdeen St., Chicago 7, Ill.

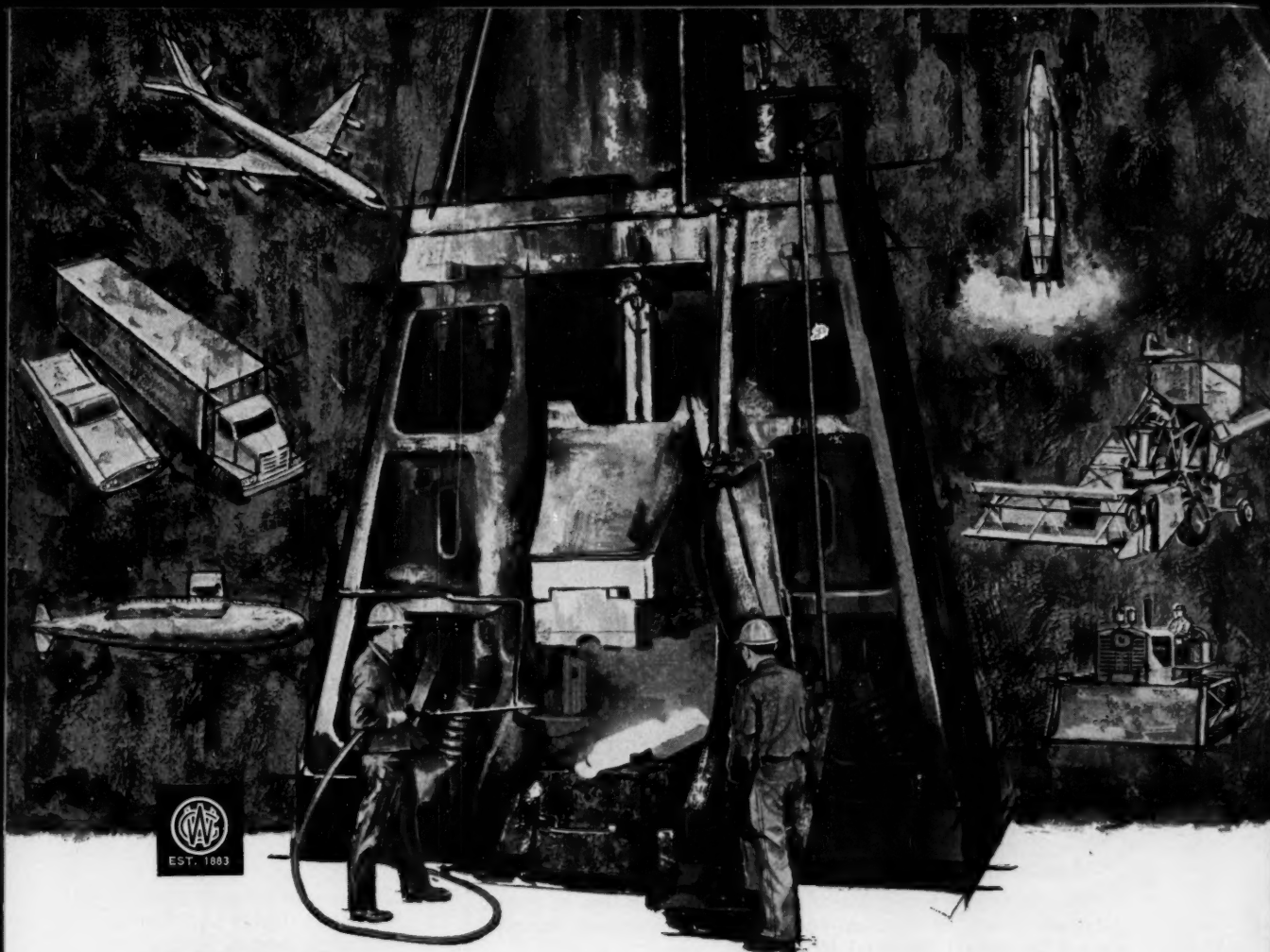
Circle 682 on Page 19

Diazo-Blue Paper

has fast exposure speed

No. 214S diazo-blue paper offers 20-25 per cent faster exposure speed than other diazo papers. It yields a bright blue image on a clean white background, develops fully at printing speed, and has excellent shelf and print life. Tecnifax Corp., Holyoke, Mass.

Circle 683 on Page 19



GIVING METAL NEW MUSCLE BY FORGING

*... a specialty Wyman-Gordon knows best
and is best equipped to perform for you*

Specify "punishing service" in any environment—land, sea, air or space—and there is no substitute for a forging's endurance. Likewise, specify reliability in your supplier and there is no substitute for experience.

Here Wyman-Gordon has the outstanding record. Our background in hot working all forgeable materials covers more than three-quarters of a century. From it have come most of today's major advances—in forging techniques, metallurgical controls and development of facilities for extending size and complexity of forged parts. This accumulated know-how has done much to make Wyman-Gordon "forging headquarters" for an impressive list of industrial leaders.

Most likely our experience in saving weight, adding strength and reducing machining cost on countless other parts—can do as much for yours. To get expert appraisal, ask to have a forging engineer call while designs are still on the board.

WYMAN - GORDON FORGINGS

of Aluminum Magnesium Steel Titanium ... and Beryllium Molybdenum Columbium and other uncommon materials

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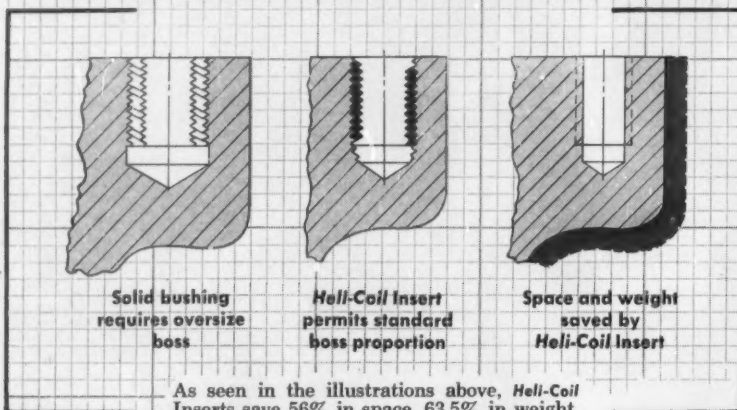
LOS ANGELES CALIFORNIA

PALO ALTO CALIFORNIA

FORT WORTH TEXAS

Circle 534 on Page 19

How You Can Save Boss Space and Weight in Thread Design ...with HELI-COIL® Inserts



Heli-Coil stainless steel wire inserts have a smaller outside diameter than any solid bushing. Therefore, with Heli-Coil Inserts you can design boss radii to a minimum, yet stay with standard boss configurations. This means *savings in space and weight*, and material-savings as well.

This feature is vitally important for miniaturization in aerospace design, in electrical and electronics equipment design, and for general industrial applications.

NO OTHER TYPE OF INSERT OFFERS SUCH SAVINGS!

Heli-Coil Standard Insert for stronger, smoother, lifetime threads

Permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration, and shock. Made of 18-8 stainless steel wire, this precision-formed Heli-Coil Insert has a tensile strength of approximately 200,000 psi. Conforms to military standards and all commercial and industrial thread forms.

Heli-Coil Screw-Lock Insert eliminates lock wiring and lock nuts

This one-piece wire Screw-Lock Insert provides all the thread protection of the Standard Insert, PLUS an exclusive resilient *internal* locking feature that eliminates clumsy protruding lock nuts, lock wiring and other supplementary locking devices. *It saves cost, space and weight* — permits simple streamlined design in standard bosses. Meets military and N.A.S. specifications for locking torque and vibration.

The Heli-Coil line of products includes: inserts and related taps, hand tools, power inserting tools, automated tooling, and gages. Tables of boss radius and weight comparison are available. Write for complete details and design data.



HELI-COIL CORPORATION

501 Shelter Rock Lane, Danbury, Connecticut

In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD.
6975 Jeanne Mance St., Montreal 15, Que.

THE ENGINEER'S

Library

Recent Books

Creative Engineering Design—By Harold R. Buhl, Dept. of Mechanical Engineering, Iowa State University; 195 pages, 7 by 9 1/4 in., clothbound; published by Iowa State University Press, Ames, Iowa; \$3.95 per copy.

Specific phases of engineering problem solution, and traits of the creative engineer and supervisor are discussed. Obstacles to creativity are analyzed.

Factors in design creativity are separately investigated: Challenge, recognition, definition, preparation, analysis, synthesis, evaluation, and presentation. Sample problems, references, and pertinent quotes are included.

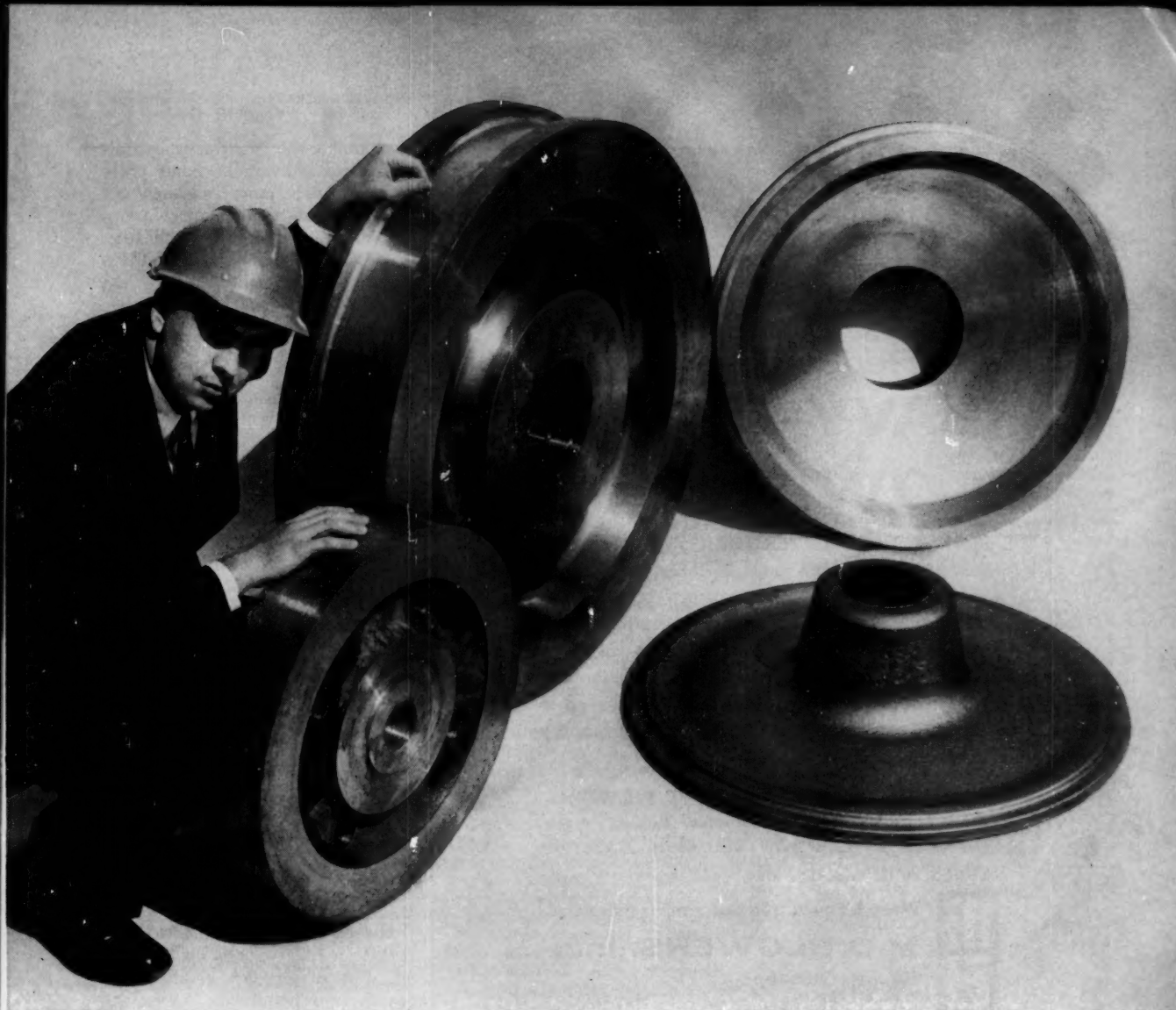
Annual Review in Automatic Programming, Volume I. Edited by Richard Goodman, senior lecturer in charge of computing, Brighton Technical College; 300 pages, 6 1/4 by 10 in., clothbound; published by Pergamon Press Inc., 122 East 55th St., New York 22, N. Y.; available from MACHINE DESIGN, \$10.00 per copy, postpaid.

Papers contained in this volume were read at the April, 1959, working conference on automatic programming of digital computers at Brighton, England.

Some specific topics covered by the 18 papers are application of formula translation to automatic coding of ordinary differential equations, problems of a universal autocode, operational experience with Pegasus autocode, and future trends in automatic programming. In addition to the 18 papers, two pioneer papers on computable numbers and a bibliography are presented.

Ingenious Mathematical Problems and Methods. By L. A. Graham; 237 pages, 5 1/4 by 8 in., paperbound; published by Dover Publications Inc., 180 Varick St., New York 14, N. Y.; \$1.45 per copy.

This collection of 100 authentic mathematics problems selected from the *Graham Dial* is designed



Bethlehem circular forgings are available in carbon, alloy, and stainless steels, and some heat-resistant grades. 10 to 48-in. OD. 100 to 2,000 lb. As-rolled or rough-machined to specifications.

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But that's where the competition ends.

Due to the hot working of the metal (our unique Slick Mill forges and rolls a circular product in one operation in one minute), forgings have better physical properties, greater strength than castings.

HIGHER CUTTING SPEEDS—The uniform quality of Bethlehem circular forgings allows you to use higher cutting speeds. Machining time—both in roughing, and in hobbing

teeth—is cut; tool life is increased. And there's no chance of sand damaging valuable hobbing tools.

LESS METAL—You'll find, in many cases, weight can be reduced. The greater strength of a *forged* circular product permits thinner rim sections without sacrificing strength.

Our sales engineers will be happy to give you the whole story on Bethlehem circular forgings—competitive initial cost, sure machining savings, possible weight savings, a better-quality product all around.

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Export Sales: Bethlehem Steel Export Corporation

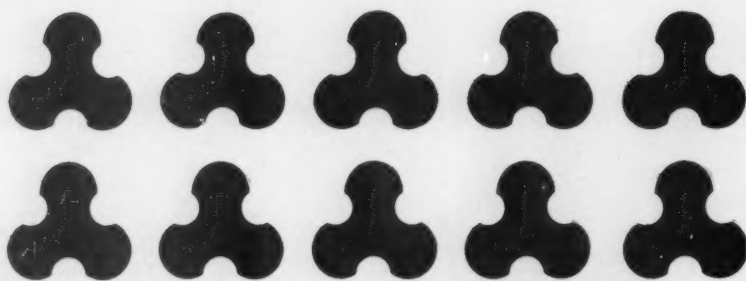


for Strength
... Economy
... Versatility

BETHLEHEM STEEL

Circle 536 on Page 19





New! Redesigned **M-D** **HEAVY-DUTY** **BLOWERS...**

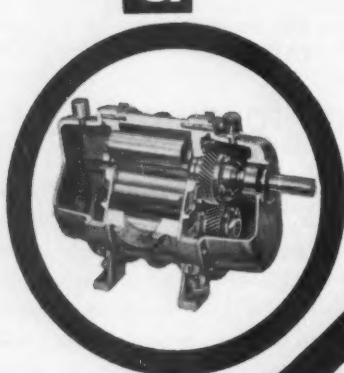
M-D BLOWERS ARE BETTER THAN EVER! 12 new features have been added to make M-D blowers even more rugged and reliable and to guarantee positive oil-free flow under the most severe operating conditions. These improvements plus M-D's exclusive 3-lobe rotor design (which eliminates the possibility of rotor deflection at high speeds) permit operation at constant pressures up to 15 PSIG in single-stage and to 70 PSIG in multi-stage with capacities ranging from 30 to 4000 CFM.

SPECIFY M-D ROTARY POSITIVE BLOWERS
FOR: Smallest Cube Dimensions • Widest Pres-
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Tested). Oil-Free Air Flow

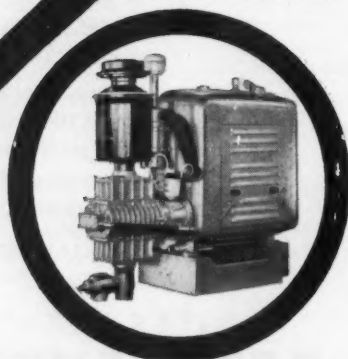



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ENGINEER'S LIBRARY

to stimulate the creative, analytical minded individual. Some problems require more alertness of thought than mathematical training; others demand the application of advanced mathematics. About 25 "quickies" test the reader's speed in solving problems. Answers are provided for all problems.

Association Publications

Recommended Dimension Identification Code for Fluid Power Cylinders. 24 pages, 8½ by 11 in., paperbound, stapled; published by National Fluid Power Association, 5595 N. Hollywood Ave., Milwaukee 17, Wis.; \$1.00 per copy.

This publication comprises recommended standards for locating base points and dimensions of fluid-power cylinder diagrams, and a code of letters for designating dimensions. Recommendations cover various types of mountings, and can be applied to all cylinders regardless of type of construction.

Horsepower Ratings of American Standard Roller Chains. 12 pages, 8½ by 11 in., paperbound, stapled; published by Association of Roller and Silent Chain Manufacturers, 3343 Central Ave., Indianapolis, Ind.; \$1.00 per copy.

Horsepower ratings applicable to American roller chains are presented. Ratings represent results of research on roller impact forces, dynamic tension forces, efficiency, and wear life.

Elevated-Temperature Properties of Aluminum and Magnesium Alloys. 308 pages, 8½ by 11 in., paperbound; published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; \$7.00 per copy.

Tensile and creep-rupture properties of aluminum and magnesium alloys at high temperatures are summarized. Included are wrought and cast alloys in such forms as rolled, forged, or extended rod; plate, sheet, and sand and permanent-mold castings.

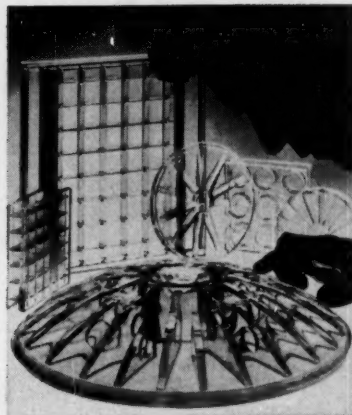
Title sheets for each alloy give alloy designation, composition, and pertinent specifications of forms of the material. Data sheets present a description of the material and strength values for mechanical properties of these alloys.

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS



FROM CORNING



99.999+% PURE FUSED SILICA

Astronomers are notoriously strict about materials. Well they might be, since a minor deviation in an optical material makes for catastrophic miscalculations when extrapolated through the infinity of space.

A new fused silica which we developed is eliciting quiet approval, the most anyone expects, from the meticulous astronomer. Drop to the molecular level and you will find only several parts of impurity per million of silica.

Such purity is naturally beneficial to the optical properties of the material. It has an extremely high degree of optical homogeneity. When you talk visible or ultraviolet light, it is the most transparent glass we have ever made. On the physical side, it has a coefficient of expansion of $5.6 \times 10^{-7}/^{\circ}\text{C}$. Its refractive index is $n_D - 1.4584$. Birefringence constant: $3.40 \text{ m}\mu/\text{cm}/\text{kg}/\text{cm}^2$. Neither gamma nor X-rays darken it.

Among some of the various products that we have made or are presently working on are telescope mirrors up to 80 inches, ultrasonic delay lines; windows for wind tunnels, high temperature viewing and star guidance systems.

We can play a few tricks with this fused silica in designing. Witness the unique sandwich construction of the mirror blanks above. This simple design innovation cuts as much as 50% off the weight of the mirror blanks without sacrificing rigidity one whit.

The coupon is your invitation to get more information on this new Corning material.

WILL THE MACHINE GIVE WAY TO CHEMICALS?

The dial faces shown above right were made without the assistance of a single die or jig, without grinding or cutting or drilling or milling or stamping or any other



mechanical operation.

We made them by exposing photosensitive glass to a precisely drawn pattern and a series of chemical etchants.

This is more than a parlor trick.

It is a method of making parts precisely which would be impossible or far too costly to make mechanically. It is the FOTOFORM® process.

We make brush holders for digital computers which call for rectangular holes measuring $0.0075" \times 0.015"$.

We can take a square inch and riddle it with as many as 250,000 holes, each precisely like all its neighbors. Or, with a simple inexpensive change in art work, we could make just one of those 250,000 holes a triangle.

The material itself is nonporous and dimensionally stable glass, utterly free of flaws and voids and able to operate continuously at 500°C .

We can use the same process on FOTO-CERAM,® one of our glass-ceramics which has a coefficient of expansion nudging zero.

If you would like to know more about chemical machining and the photosensitive glasses, please send the coupon.

FOR 10^{-6} mm Hg GREASELESSLY

With all due apologies to the people who make grease, it is usually a nuisance in



vacuum lines.

It's also a likely source of contamination.

So, we say, get rid of grease.

There are recesses in the sockets of this joint which match to perfection the configuration and dimensions of a Buna-N O-ring.

Even without grease, this seal will hold a vacuum down as far as 10^{-6} without leaking.

The assembly accepts a standard socket and clamp.

The glass is PYREX® brand No. 7740, so it will not serve as a source of contamination either. It's easily worked to fit into any setup, so it should be in demand for more than the usual bench-top vacuum line. There should be considerable demand among people everywhere who want a tight, greaseless joint.

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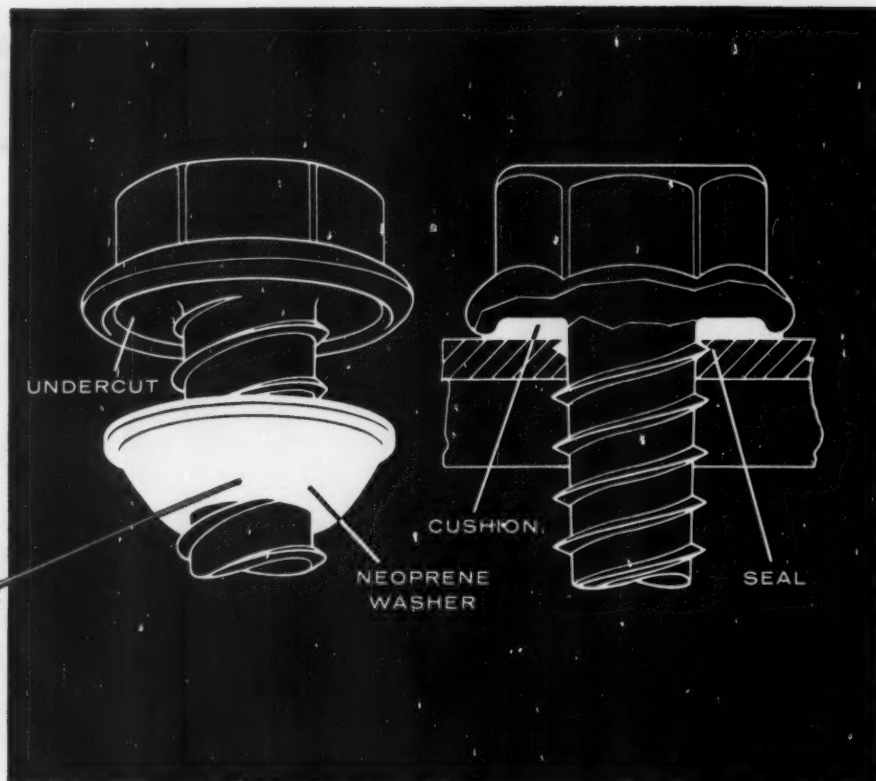
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NAT'S
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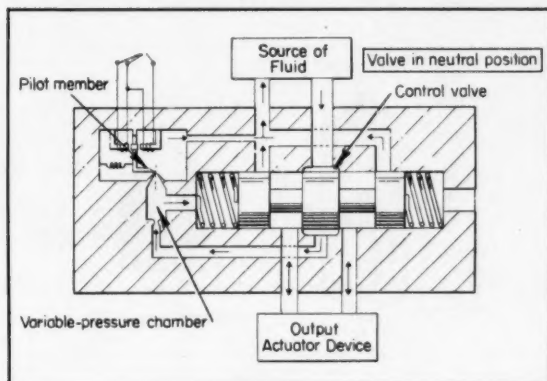
California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

NOTEWORTHY

Patents

Electrohydraulic Servo Valve

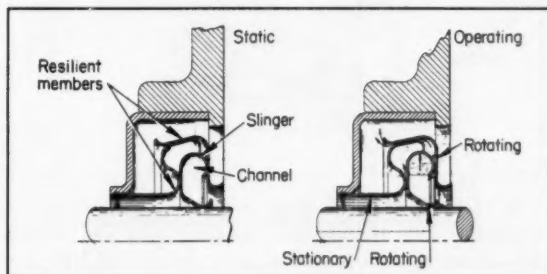
An electrically actuated pilot member regulates the opening in a jet-stream orifice to control a two-stage hydraulic servo valve. Position of the pilot member, which moves transversely across the jet stream, determines the pressure in a variable-pressure chamber. This pressure, in turn, operates the control valve. Because the pilot member moves transversely to the jet-stream axis, servo valve operation is unaffected by



variations in system pressure. The design provides a high degree of sensitivity together with maximum hydraulic amplification. A degenerative feedback system couples the control and pilot valves, so that the pilot member may move back to its equilibrium position in response to control-valve displacement. Patent 2,962,002 assigned to Sanders Associates Inc., Nashua, N. H., by Paul F. Hayner.

High-Speed Rotary Shaft Seal

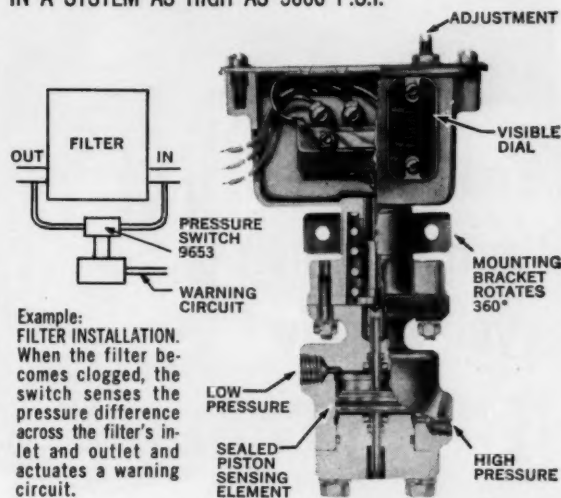
High-speed slinger-type rotary shaft seal operates between two resilient members to provide sealing whether the shaft is rotating or at rest. During shaft



rotation, hydraulic pressure deflects the resilient members away from the slinger and from each other, pro-

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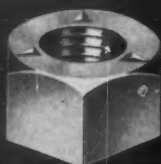
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PRESSURE SWITCH DIVISION

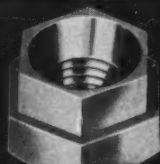


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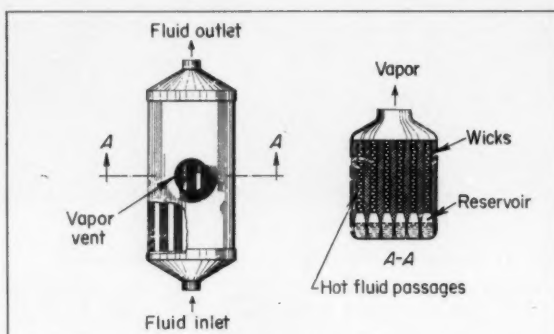
Subsidiary of Heli-Coil Corporation,
Danbury, Conn.

NOTEWORTHY PATENTS

viding passage for a controlled fluid film that lubricates the assembly. Pressure acting on the annular channel in the slinger causes it to spring slightly away from the shaft, so that the speed of the slinger is controlled by the hydraulic shear factor of the fluid. Thus, when the shaft is operated at high speed, the seal assembly rotates at a slower speed, minimizing wear on the seal members. When the assembly is at rest, the seal members are firmly pressed together. Patent 2,960,356 assigned to Tyce Engineering Corp., Chula Vista, Calif., by Roland Tyce and Walter T. Czuba.

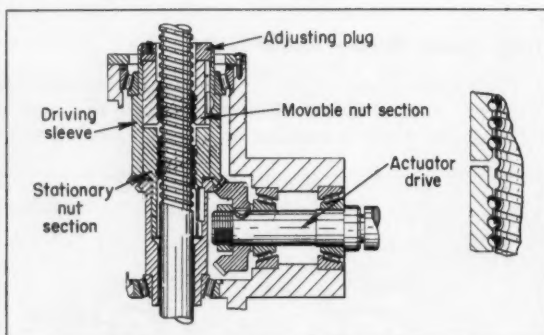
Heat Exchanger

A wick-type heat exchanger operates effectively in any position. Hot fluid flows through passages sandwiched between layers of fiber glass wick. Cooling fluid is contained in a reservoir and soaked up by the wicks, providing a constant supply of coolant to the cooling surfaces. Vapor produced by heat transfer is ex-



hausted through a port. Use of the wick material prevents the formation of a vapor film on the cooling surfaces. The fluid passages may be finned to provide additional cooling surface. Patent 2,960,847 assigned to Stewart-Warner Corp., Chicago, Ill., by Donald A. Potter.

Antibacklash Power-Screw Nut

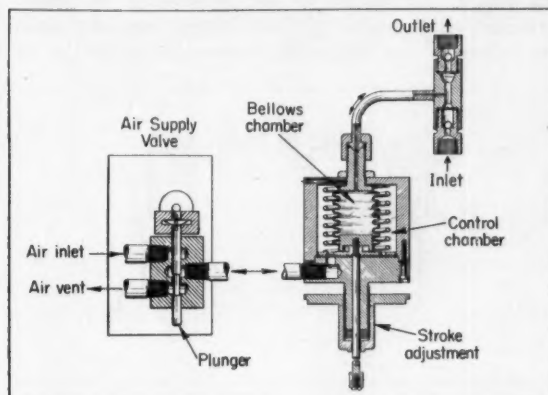


A recirculating-ball screw actuator uses a two-piece actuating nut to eliminate backlash and lost motion. An adjusting plug is turned until the helical ball races in the two nut sections are sufficiently offset so that backlash is eliminated. At this point the balls no longer ride on the bottom of the helical grooves, as

shown. The nut is keyed to the driving sleeve, preventing lost motion. This arrangement can also be used with conventional screw drives. *Patent 2,959,976 assigned to Kearney & Trecker Corp., West Allis, Wis., by Frank Zankl.*

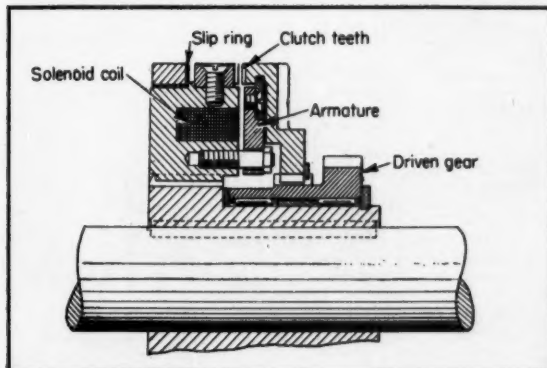
Metered-Flow Bellows Pump

A bellows in a pneumatically operated fluid pump is actuated by compressed air metered to the pump through a motor-driven air valve. Absence of wear, which usually occurs in mechanical-drive pumps, prevents loss of accuracy during prolonged operation. A cam-actuated plunger controls the supply of compressed air to the bellows. When the air-supply valve is open to vent, as shown, air is exhausted from the control chamber, the bellows expands, and the system fluid



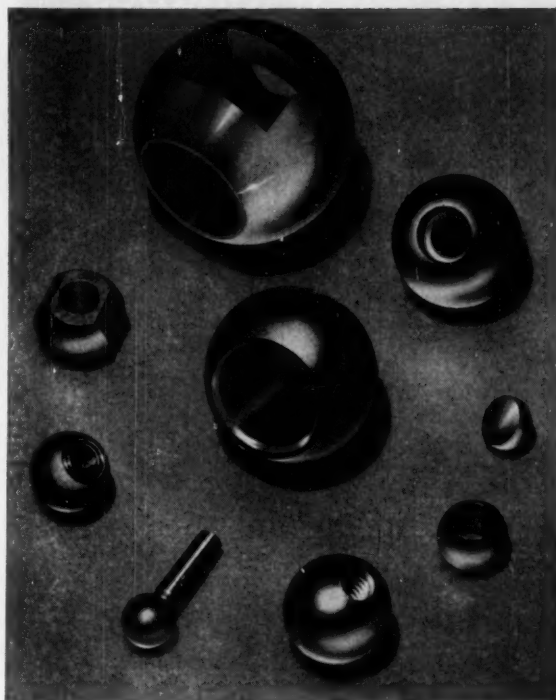
is drawn into the bellows chamber through a check valve. The pumping cycle is completed when the supply valve provides air to compress the bellows, forcing the fluid from the bellows chamber through the outlet port. Both system fluid ports are controlled by check valves, and length of the pump stroke can be adjusted. *Patent 2,960,038 assigned to Phillips Petroleum Co. by Dale E. Lupfer, Daniel M. Vesper, and Emerick Guenther.*

Electromagnetic Clutch



Toothed faces are used to transmit torque in an electromagnetic clutch, while the armature and magnetic

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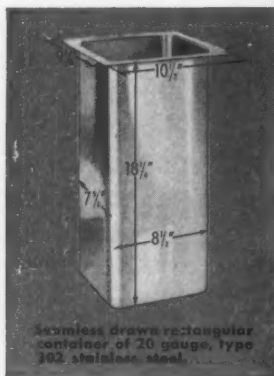
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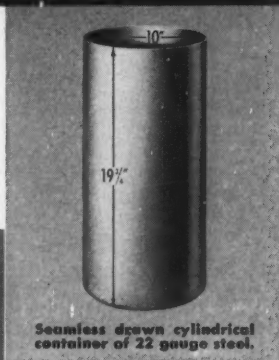
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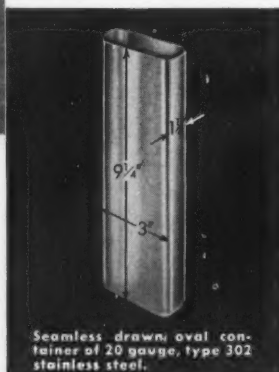
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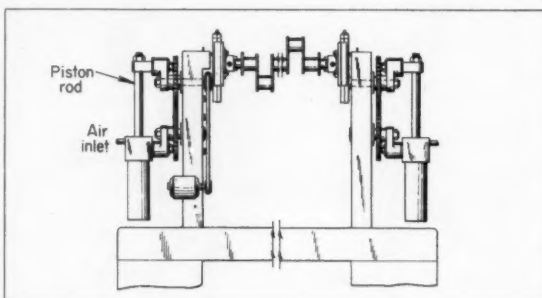
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NOTEWORTHY PATENTS

coil are used only to engage the clutch. Thus, vibration in the drive system is not transmitted to the clutch-actuating mechanism. Since the armature and coil are not designed to transmit torque, a light construction can be used, providing a compact clutch assembly. Power to energize the clutch is provided through a nonrotating slip ring. Patent 2,962,142 assigned to I-T-E Circuit Breaker Co., Philadelphia, Pa., by Herman W. Straub.

Pneumatic Counterbalance

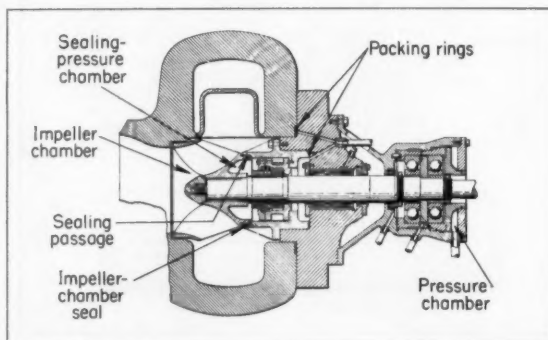
Theoretically exact counterbalancing of a rotating part is provided automatically by a pneumatic piston-and-cylinder assembly which is free to pivot on two bellcranks. Any unbalance force set up by the rotating part is transmitted to the piston rod. A predetermined air pressure in the cylinder, combined with the action of the bellcranks, causes the piston to set



up an opposing force which neutralizes the unbalanced forces. An accumulator absorbs sudden pressure surges, so that the pressure in the cylinder is always nearly constant. Thus, regardless of the angular position of the part, the system can still effectively neutralize unbalanced forces. Patent 2,961,806 assigned to Lemco Products Inc., Bedford, Ohio, by James J. Strnad.

Leakproof Centrifugal Pump

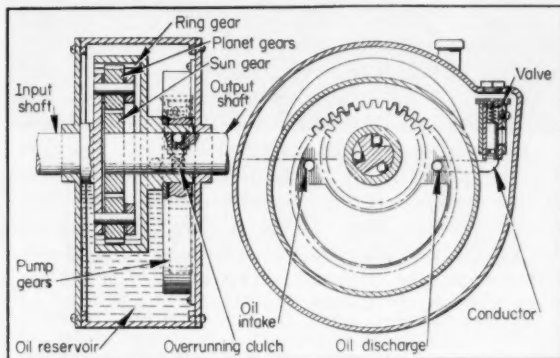
Both static and dynamic seals are used in a centrifugal pump to assure completely leakproof operation. While the pump is at rest a pair of standard packing



rings, together with a static impeller-chamber seal, contain the system fluid in the pump. When the pump

is in operation, however, the static seal is no longer effective. Fluid under pressure is supplied to the pressure chamber, causing the shaft to shift axially toward the impeller chamber. This movement disengages the static seal, while pressure builds up in the sealing-pressure chamber. Sealing fluid flowing from this chamber to the impeller chamber blocks leakage of fluid from the impeller chamber. An automatic shut-off guards against loss of sealing-fluid pressure. Patent 2,960,938 assigned to Worthington Corp., Harrison, N. J., by John G. Williams.

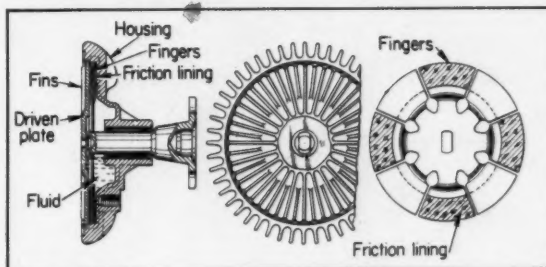
Variable-Torque Transmission



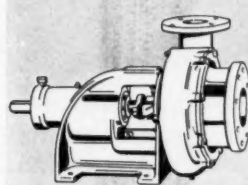
Automatic transmission uses hydraulically-controlled planetary gear train to regulate drive ratio. When power is first applied to the input shaft, the planet

gears revolve about the stationary sun gear, driving the ring gear at maximum angular velocity. The ring gear, in turn, drives a gear-type oil pump which delivers oil under pressure to the planetary train. The oil, in its passage through the gear system, imposes a restraining force on the ring gear, reducing its angular velocity. Torque developed by this action drives the sun gear at an increasing speed. When the speed of the sun gear reaches that of the ring gear, a one-way clutch "locks up" the system, to prevent overspeeding of the output shaft. Patent 2,960,890 assigned to Welex Inc., Fort Worth, Tex., by Frederick L. Davis.

Hydraulic-Mechanical Power Coupling



Spring-loaded coupling design operates as a mechanical friction clutch at low input speeds, and as a fluid coupling at high input speeds. At low input speed,




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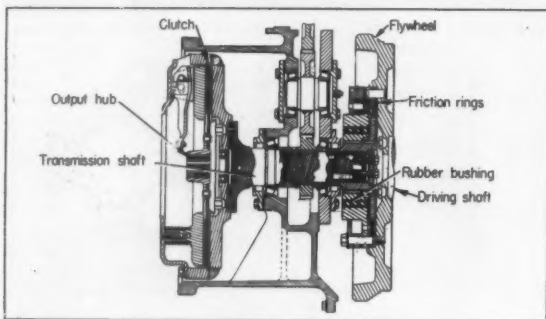
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NOTEWORTHY PATENTS

spring-loaded, friction-faced clutch fingers are pressed against both the housing and the driven plate. The unit then acts as a wet clutch to provide direct drive without slippage. As input speed increases, the fingers tend to straighten and draw away from their contact surfaces. At this point coupling action is dependent solely on the shearing action of the coupling fluid, which is carried to the contact areas by centrifugal force. Heat dissipation is provided by the circular movement of the system fluid and the fins formed into the driven plate. *Patent 2,963,135 assigned to Schwitzer Corp., Indianapolis, Ind., by Thomas J. Weir.*

Shock-Absorbing Power-Takeoff



A rubber bushing is used to transmit torque in a power-takeoff transmission. Variations in the angular

velocity of the flywheel, caused by the power impulses of a multiple-cylinder internal-combustion engine, are absorbed by the bushing so that a virtually constant transmission-shaft speed is maintained. In addition, the transmission shaft is isolated from stop-start shocks or torsional vibrations generated by the flywheel. Vibration and shock-absorbing friction rings are provided in the flywheel assembly to guard against premature failure of the rubber bushing under abnormal load conditions. *Patent 2,961,893 assigned to LeTourneau-Westinghouse Co., Peoria, Ill., by Walter D. Cashman and Ernst W. Spannake.*

Magnetic friction clutch with lubricated gripping surfaces is free from galling of soft-iron pole-piece faces when the clutch is engaged. One face is covered with a film of soft non-ferrous metal such as bronze. The film is thin enough so that there is no objectionable nonmagnetic gap between gripping surfaces. The film fills the natural gaps in the ferrous pole-piece faces so that heavy engaging pressures do not cause high spots to be torn away. Buildup of material between the pole faces, which reduces the efficiency of the clutch, is thus eliminated. *Patent 2,958,406 assigned to Warner Electric Brake & Clutch Co., South Beloit, Ill., by William C. Pierce.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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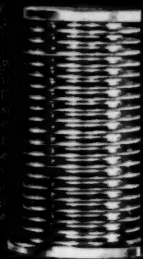
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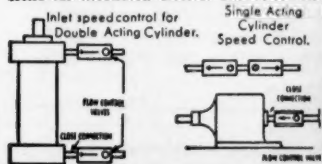
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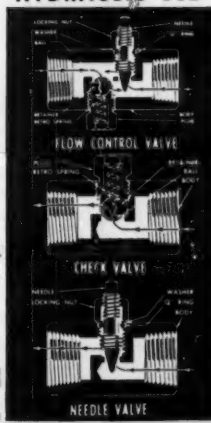
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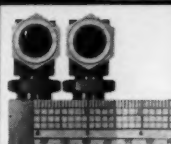
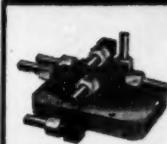
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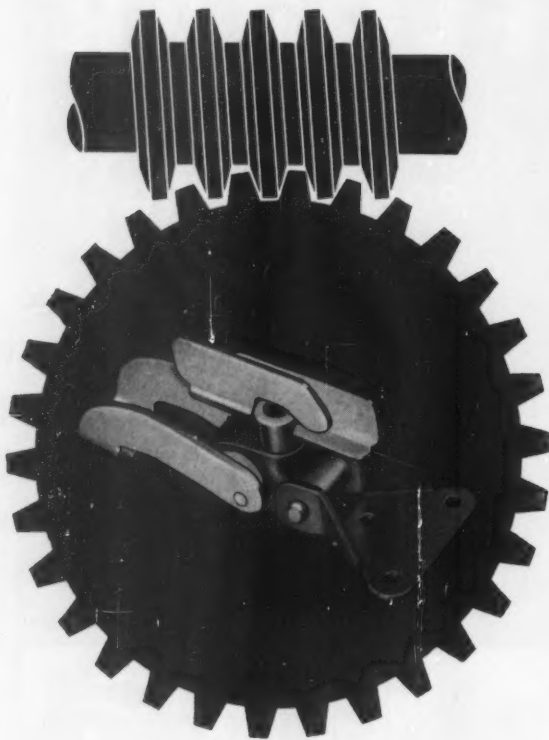
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Circle 548 on Page 19

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Circle 552 on Page 19



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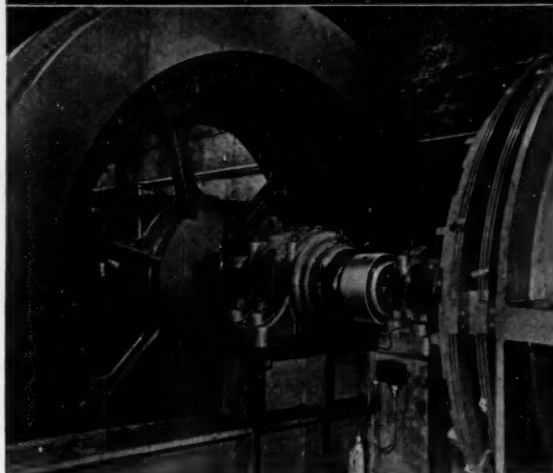
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SPECIFICATION	Sier Bath	Coupling A	Coupling B	Coupling C	Coupling D	Coupling E
SIZE	5 1/2	6	6	6	6	11
MAXIMUM BORE (inches)	6	6	6 3/8	6 3/8	6 1/2	11
AVAILABLE HP CAPACITY FOR APPLICATION	1500	1800	1650	1350	1575	1600
LENGTH (inches)	8 1/4	16	12 3/8	13 3/8	12 3/8	20 1/4
DIAMETER (inches)	11 1/4	16 1/8	17 1/8	15 1/4	16 1/8	32 1/2
WEIGHT (lbs.)	153	650	400	500	525	1990
FACTOR OF SAFETY	7	6	5	6	6	5
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Sier-Bath

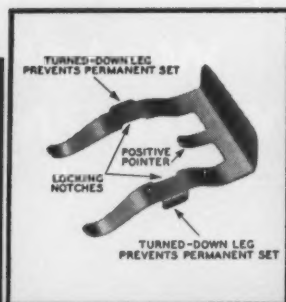
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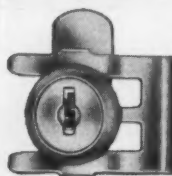
Spring steel clip locks into fastening grooves.



Side view—clip holds lock firmly against metal.



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Clip in place on Corbin C15258 disc tumbler cam lock. Also available on other cylinder locks.



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For All Rotating Equipment the ROTARY UNION®



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Circle 556 on Page 19

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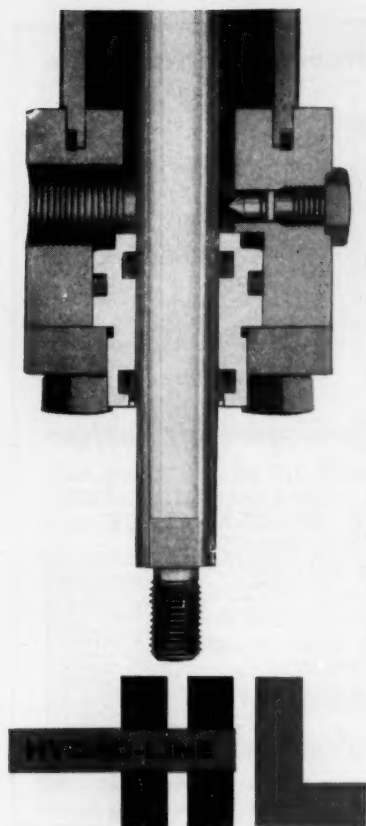
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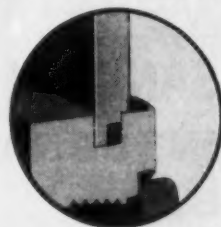
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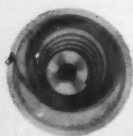
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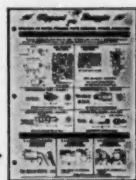


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Patent No. 2908310

ND NUT — for projection welding. Ideal where tension is against the weld.



PN NUT — for projection welding. Ideal in confined areas, to heavier gages and on curved surfaces.



Patent Applied For

XN NUT — for spot welding with recessed target electrode area. Full range of sizes can be welded with 20 KVA Welder.

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Circle 564 on Page 19



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Compression & Tension Type

Aircraft cable is strung with spherical steel shells in a rigid or flexible housing sealed with "O" rings. 3" standard bend radius. 1/4" minimum bend radius.

Three Types:

1. **Light Duty**—Compression Ult. Load 1250 lbs.; Ult. tension 960 lbs.
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Positive remote controls for actuating mechanical, hydraulic or other devices. Eliminate bell cranks, pulleys and dual cables. U. S. Patent No. 2441719. All world rights reserved. Send for **ENGINEERING MANUAL No. 1551** giving complete specifications covering materials, finishes, capacities. Please address Dept. MD-PP-61.

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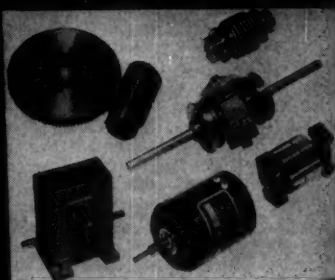
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Circle 566 on Page 19



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**FAST - LOW COST
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Circle 567 on Page 19

Sensitive DIFFERENTIAL PRESSURE and VACUUM CONTROLS

J6K
J27KB



By using UNITED ELECTRIC's Type J6K or Type J27KB control, it is possible to control accurately the difference in pressure between two pressure or vacuum sources. The J6K contains a single switch; the J27KB is a dual switch control.

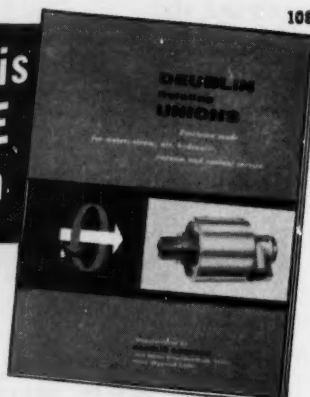
System Differential	Up to 90 psi.
Switch Differential	J6K — can be set between limits of $\frac{1}{2}$ " Hg and 3 psi. J27KB — can be set between limits of 1" Hg and 5 psi.
Switch Ratings	15 amps. at 115 or 230 volts A.C. Also 20 amps. or D.C. switches on specification.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
Adjustments	J6K — internally located, uncalibrated adjustment wheel. J27KB — each switch has independent, uncalibrated adjustment screw.
Electrical Connections ..	Made to screw terminals on switches through clearance hole in enclosure.
Pressure Connections ...	Two $\frac{1}{4}$ " female NPT pressure connections.
Size	J6K — $7\frac{5}{8}$ " x $4\frac{3}{4}$ " x $2\frac{5}{8}$ ". J27KB — $7\frac{1}{16}$ " x $6\frac{3}{8}$ " x $2\frac{1}{8}$ ".
Approximate Weight	J6K — $2\frac{3}{4}$ lbs. J27KB — 2 lbs.

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Thumb & Wing Screws

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Screws

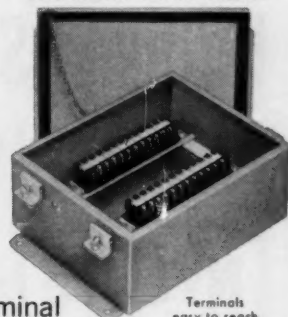
Hex Nuts

Washers

Screw
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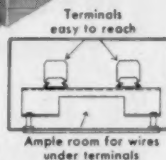
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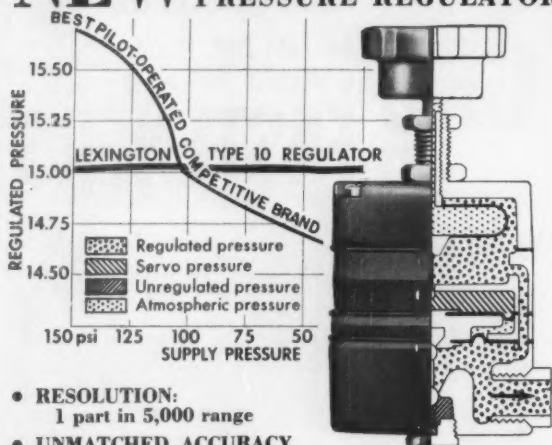
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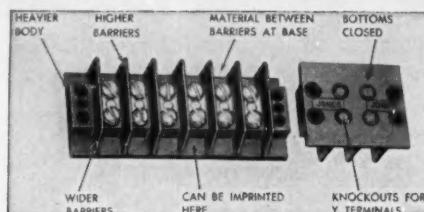
The exclusive use of *regulated air pressure* instead of supply pressure is the secret of unmatched performance. Constant reliability results from stainless steel pressure capsule which assures stable movement under all ambient temperatures. Three pressure ranges: 2-25; 3-60; 3-125 and NPT pipe sizes $\frac{1}{8}$ ", $\frac{1}{4}$ " and $\frac{3}{8}$ ". Write for bulletin or send purchase order. Unconditionally guaranteed to perform in accordance with above curve for Lexington Regulator type 10. (Protected by U.S. and foreign patents) Price: \$20.00 plus postage with quantity discounts.

Lexington Controls
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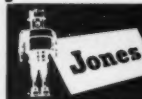


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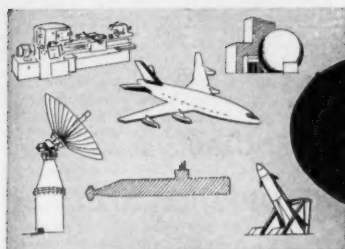
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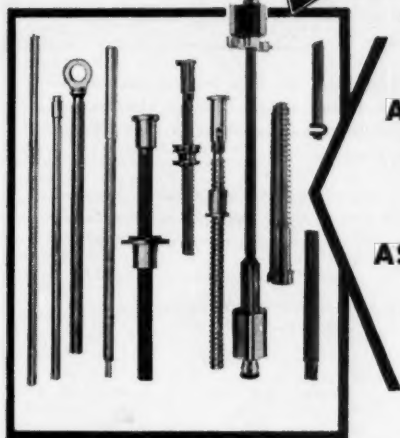


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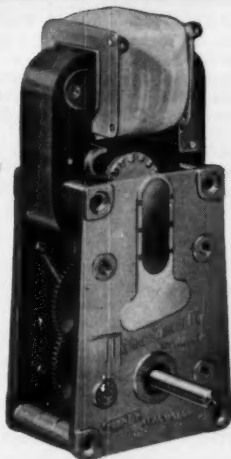
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SPECIAL ELECTRICAL EQUIPMENT

Circle 579 on Page 19

**ROTARY AIR
GAST
PRODUCTS**



Model 2065 with motor,
Gast base and coupling.

Solve your product problems — specify positive displacement GAST AIR COMPRESSORS



Model
0465



Model
1065



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Model
4565

To enjoy excellent performance-per-pound . . . through years of demanding service . . . specify Gast heavy-duty Air Compressors. Forced-air dual fan cooling and automatic lubrication permit 'round-the-clock operation at rated pressures.

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As original equipment or for plant service, they may help you solve design problems! May we send complete data?

Model No.	Rec. Max. Pressure, p.s.i.g.				Net Wt.* Lbs.
	C.f.m. @ 0 p.s.i.g.	Con- tinu- ously	Inter- mittent	Motor h.p.	
0465	4.0	25	30	1/2	18
0765	5.9	10	15	1/2	18
1065	8.3	25	30	1	33
2065	17.0	15	20	1 1/2	52
2565	21.0	15	20	2	51
4565	45.0	15	20	5	92

*Without base or electric motor.

WRITE TODAY FOR BULLETIN P-HD.

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ROTARY**

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Circle 580 on Page 19

235

MECHANICAL ENGINEERS

Bausch & Lomb

There are several openings for Senior Design Engineers in the Product Design sections of our company.

These openings are permanent positions requiring the ability to take Mechanical Design responsibility from specifications to a saleable product. Products involved are mechanical-electrical-optical in nature. A Mechanical Engineering Degree and at least 6 years of mechanical design experience is required. No optical or electrical background is necessary, but would be helpful in certain openings.

These positions require board design, coordination of customer requirements with Electrical and Optical Designers, supervision of detail draftsmen, assistance to shop during construction and assembly as well as testing and development work.

Those who can qualify and are interested in real design responsibility are invited to submit a resume to: Mr. H. A. Frye, Professional Employment.

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ENGINEERING OPPORTUNITY

Expanding and progressive automotive parts manufacturer located in Southeastern Wisconsin has a key opening for man capable of supervising a department consisting of 20 to 30 process and manufacturing engineers. This position offers direct responsibility for a group whose function is the design and development of special purpose equipment and processes from inception, through release, to manufacturing.

As a department head this man will be required to originate and to channel original ideas for the development of new processes and equipment to meet specific manufacturing needs.

Salary will be determined by his qualifications; his rate of advancement by his results. Excellent working conditions with capable associates and liberal company benefits. Reply:

Box 982, MACHINE DESIGN, Penton Bldg.
Cleveland 13, Ohio

ENGINEERS AVAILABLE OR WANTED

AVAILABLE: Mechanical Engineer, advanced degree, development of automatic and special machinery and mechanisms. Mechanics, hydraulics, stress and automation. Supervisory experience in development and production. Ready to assume responsibility. Address Box 983, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Assistant Professor teaching position in Mechanical Engineering Department, University of Nevada, Reno, Nevada, available in fall 1961. M.S. degree in M.E. and some additional experience is desired. Write to chairman.

WANTED: DEVELOPMENT ENGINEER. Develop advanced manufacturing production equipment and systems for widely varying applications. High analytical, technical and inventive abilities required plus minimum of five years experience in design of production machinery and controls. M.E. degree required with additional consideration given advanced degree. Send resume and salary requirements to: Mr. Howard E. Lutz, Jr., Westinghouse Electric Corporation, P. O. Box 2278, Pittsburgh 30, Pennsylvania.

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

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backtalk—

—Roll Call

While taking a first-of-the-year inventory of editors, we decided to re-introduce Theodore M. Leach, who traveled halfway around



the world before settling here. Offspring of a Baptist medical missionary, Ted was born in China and lived in Huchow, "just up the river from the Chiang Kai-sheks." In fact, he recalls visiting Mme. Chiang when she entertained missionaries' children.

Came the revolution in China, and Ted, then ten years old, and his parents returned to the United States. They lived in Ohio, and when Ted reached college age he enrolled at Capital University. After receiving a B.A., he went on to Colgate-Rochester Divinity School to earn a Bachelor of Divinity degree.

He served as a minister for several years, then went to work with his hands, operating a turret lathe at Pratt & Whitney Aircraft Co. in Hartford, Conn. He soon advanced from production to inspection, and then was selected for engineering training. This took him to Hillyer College, where he received an Associate of Engineering degree. To utilize his new knowledge, P & W made him a designer of small turbine components. He was also a design engineer at Arrow-Hart & Hegeman Electric Co. for about a year.

Ted was an avid MACHINE DESIGN reader from the beginning of his industrial career, and MACHINE DESIGN returned the compliment by annexing him to its staff as an assistant editor in September, 1958.

—On Being Well Red

For a peek behind the Iron Curtain at technological developments—at least the ones that get into print—you can now subscribe to Eng-

lish translations of Russian magazines. Acta Metallurgica (122 E. 55th St., New York 22, N. Y.) offers individual subscriptions to "major Russian technical journals . . . at greatly reduced rates" to members of sponsoring and co-operating societies: American Society for Metals; American Institute of Mining, Metallurgical, and Petroleum Engineers; American Institute of Physics; and the American Society for Testing Materials.

Subject areas covered by the six magazines described by Acta Metallurgica include physical properties of metals and alloys, metallurgy of nonferrous and rare metals, powder metallurgy, welding, heat treatment, corrosion and metal protection, nondestructive testing, refractory materials, and new production techniques.

—Plastics, Powder-Metal Prizes

Honors are awaiting outstanding designs in both plastics and powder metals.

The Bachner award, sponsored by Chicago Molded Products Corp., is for excellence in the industrial application of plastics. A trophy goes to the company submitting the winning entry and \$1000 goes to the person or persons designated by the awardee as most responsible for the achievement. The competition, which closes March 10, is open to manufacturers of products which employ plastic components or are made entirely of plastics and molded, extruded, or thermoformed. Information can be obtained from Wm. T. Cruse, Chairman of the Bachner Award Committee, c/o Society of the Plastics Industry Inc., 250 Park Ave., New York 17, N. Y.

For the powder-metal set, the annual award competition sponsored by New Jersey Zinc Co. offers \$500 to each of two men most closely associated with the Nonferrous Metal Powder Part of the Year. One award goes to the man closest to conception and design of the part, the other, to whoever was most responsible for its production. Entries will be accepted from all fabricators and users of brass, nickel silver, and prealloyed bronze powder. The contest closes Feb. 28; further information can be had by writing Awards Editor, Metal Powder Press, New Jersey Zinc Co., 160 Front St., New York 38, N. Y.

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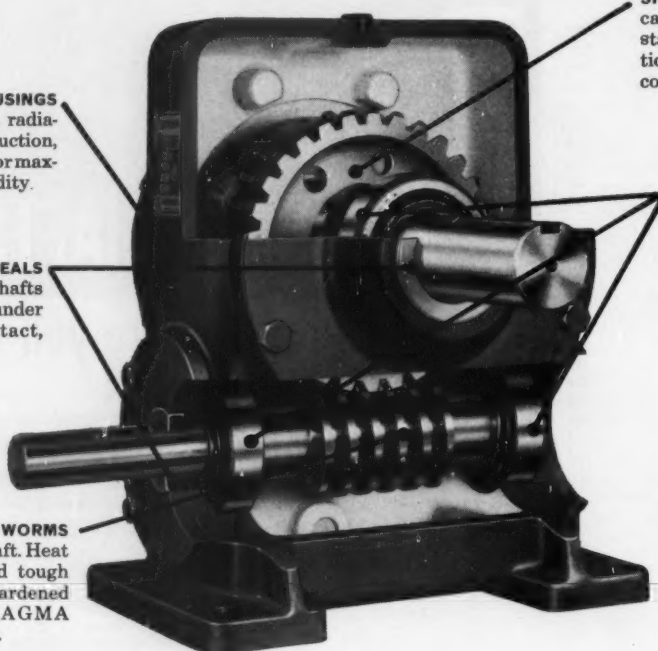
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for minimum maintenance, long bearing life, permanent shaft alignment. Capacity to handle high radial and thrust loads.

AVAILABLE in single and double reduction models, for intermittent or continuous service. Order from stock with right-angle or parallel shafts, worm on top or bottom, all worm gear or combined worm and helical. All types of special units also available.



- 108 Models
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- Max. Output Torque 142 to 34,767 in. lbs.

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For complete information on Winsmith Speed Reducers, write today or call your nearest Winsmith Representative. You'll find one in every major industrial area, listed in the Yellow Pages. They are technically trained experts who are always ready to help you with any speed reducer problem. For both standard and special power transmission applications, you'll find it pays to standardize on Winsmith.

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fastener
problem...**



and here's how Pheoll solved it

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Pheoll came into the picture and immediately reduced material costs and eliminated a bending operation; replacing a four slide part with a cold headed thumb screw. Then Pheoll dog-pointed and end-drilled the bottom of the thumb screw which allowed the attachment of a permanent spinning grip washer. Previously, this piece consisted of three parts manufactured by three separate industries.

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FOR OVER
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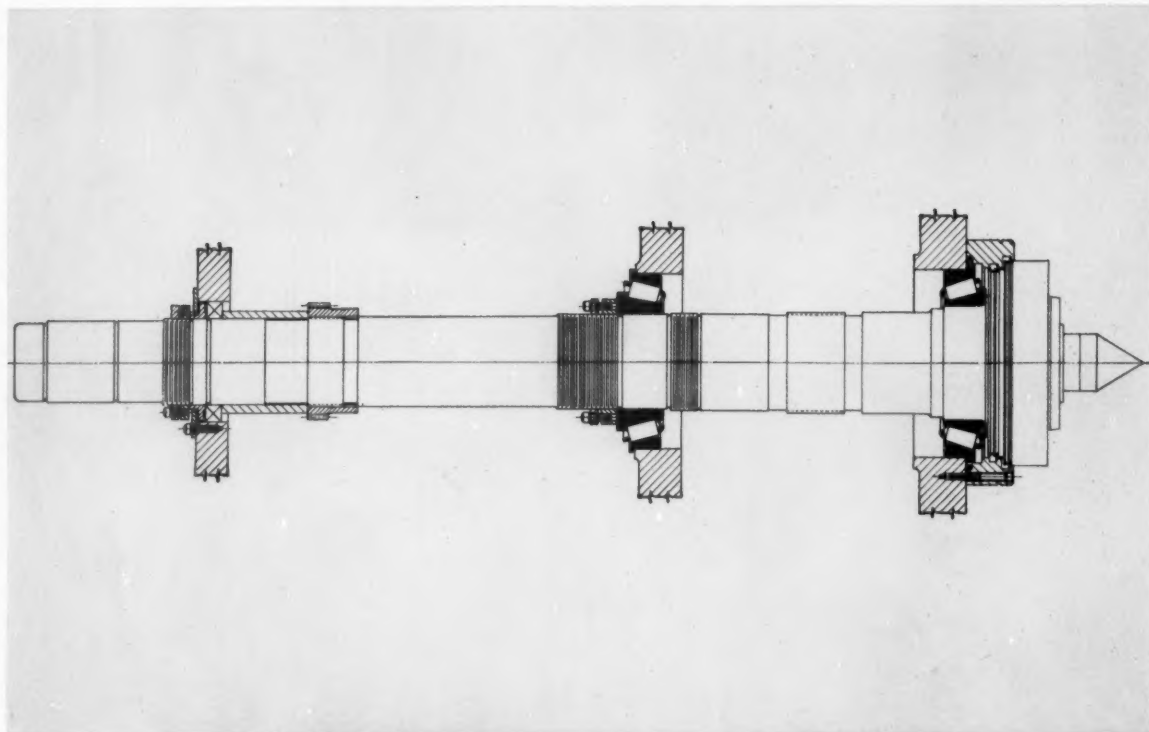
Pheoll Manufacturing Company, Inc.

5700 WEST ROOSEVELT ROAD

CHICAGO 50, ILLINOIS

Circle 402 on Page 19

How Monarch assures rigidity, accuracy, with Timken® bearings in "Dyna-Shift" lathe



IN designing their Series 90 Dyna-Shift lathe that can be kept under full load at any speed, Monarch engineers wanted to be sure of rigidity, accuracy and economy. By using 30 Timken® tapered roller bearings at vital points—spindle (shown above), gear box, apron and tailstock—the engineers achieved their objectives. Results from the "90", reports Monarch,

show up to 25% more output and 50% greater tool life than with other equipment.

Most American machine tool design engineers use Timken bearings. Two big reasons are: 1) The taper lets Timken bearings take radial and thrust loads in *any* combination. 2) Precision manufacture of Timken bearings assures high precision in the machines.



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